THE

ELECTRICAL REVIEW.

VOL. XXXVII. NOVEMBER 15, 1895. No. 938.

CONTENTS:

	PAGE
The Presidency of the Institution	593
The Carborundum Plant at Niagara	595
The History of a Great Electrical Company	595
European Incandescent Lamps	596
Alternate Current Motors (*illustrated*) (*continued*)	598
The Control of Transformer Lossses on Converting Systems of Electrical Supply (*illustrated*) (*continued*)	600
Reviews:—The Practical Engineer Pocket-Book and Diary ...	602
Elements of the Mathematical Theory of Electricity and Magnetism	602
Engineering Contracts and Specifications	602
The Use of the Controller for Electric Railways (*illustrated*) ...	603
The Rating and Behaviour of Fuse Wires (*illustrated*) (*continued*)	606
Proceedings of Societies:—Physical Society	606
Correspondence:—Incandescent Lamp Efficiencies	607
Sullivan's Universal Galvanometer	608
An Explanation	609
Block Signalling	609
Raising the Voltage of Transformers (*illustrated*)	609
Horseless Carriages	609
Overhead Wires	610
J. C. Howell, Limited	610
Cost of Steam Power...	610
Business Notices, &c.	610
Electric Lighting Notes	611
Electric Traction and Motive Power Notes	612
Telegraph and Telephone Notes	613
Contracts Open and Closed	613
Notes	613
City Notes	616
Traffic Receipts	616
Share List of Electrical Companies	617
The Arc Light (*illustrated*) (*continued*)	618
The Institution of Junior Engineers Presidential Address (*concluded*)	621
Municipal Telephony	622
New Patents	624
Abstracts of Published Specifications	624

THE
UNIVERSAL ELECTRICAL DIRECTORY
(J. A. BERLY'S).

PRICE 4/- POST FREE.
The Leading Electrical Trades Directory and the Oldest Electrical Directory in the World.

1895 ISSUE

PRICE 4/- POST FREE.
Fully Revised and Thoroughly Reliable.
Contains a larger amount of Trade Matter than any other Electrical Directory.

H. ALABASTER, GATEHOUSE & CO.,
22, Paternoster Row, London, E.C.

THE ELECTRICAL REVIEW.
Published every FRIDAY, Price 4d.
The Oldest Weekly Electrical Paper. Established 1872.
TO BE OBTAINED BY ORDER FROM ANY NEWSAGENT IN TOWN OR COUNTRY.

OFFICE:—22, PATERNOSTER ROW, LONDON.

Telegraphic Address: "AGREEAT, LONDON." Code A B C. Telephone No. 517
ALL Letters should be addressed to the Proprietors, H. Alabaster, Gatehouse & Co.

ADVERTISEMENT RATES ON APPLICATION.
The "Electrical Review" is the recognised medium of the Electrical Trades

SUBSCRIPTION RATES.—In *Great Britain*, Post Free per Year, 19s. 6d. To all *other Countries*, per Year, £1 4s.
BINDING.—Subscribers' numbers bound, including case, for 4s. each volume.
CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.
FOREIGN AGENTS.—*New York:* D. VAN NOSTRAND, 23, Murray Street. *Paris:* VEUVE J. BOYVEAU, 22, Rue de la Banque. *Berlin:* ASHER & Co., 5, Unter den Linden.
Cheques and Postal Orders (on Chief Office, London) to be made payable to Mr. H. ALABASTER, 22, Paternoster Row, E.C.

THE PRESIDENCY OF THE INSTITUTION.

THE agitation which, no long time ago, was raised with reference to the constitution of the Council of the Institution of Electrical Engineers, and which, either from want of organisation or from lack of real feeling on the subject resulted in nothing, appears to be again taking shape, although in a modified form. It is an open secret that a great deal of dissatisfaction exists with reference to what is assumed to be the choice that will be made by the Council as a body (though possibly not as individuals) of the member of the Institution who is to act as President for the ensuing year. The Council is undoubtedly in a difficult position in having to deal with the matter. The gentleman who stands next on the list for "promotion" has, as is well known, been most liberal in his pecuniary support to the Institution, and for this reason, no doubt, deserves well of it, but such liberality should really have but little weight in deciding the point at issue, and there are indications that the members of the Institution of Electrical Engineers will be called upon to regard their ballot papers at the next annual meeting with less indifference than usual. It is understood that the Council have decided to recommend Sir David Salomons for election to the presidency, and there are reasons which have been put before us from various quarters why Sir David should not be elected, but we are precluded from adopting, or even recording, these reasons, for in our issue of October 18th we indicated the only view which it seems to us can be taken in opposition to the recommendation of the Council if, in fact, their decision has been arrived at.

There are two sides to every question—more especially questions which are decided by votes—and these two sides are unfortunately often obscured by minor issues or personal feelings. The interest of the Institution is the main consideration, and this will undoubtedly be claimed as their object by both parties seeking an issue by ballot. On the one hand there is the Council, who follow the usual routine by nominating the senior vice-president. On the other hand there is the fact that the nominated president is not a practising member of the profession represented by the Institution. To us there are no other issues, and it is simply for the members to decide in which way the interests of the Institution are best served. The Council are not nominating one who is not of some prominence in the electrical world, or who is entirely deficient in original work, but the prominence

is of a commercial nature and the original work is that of an amateur. Considering the present position of the electrical industry, we could have wished that the Council's nomination had been one to call for no objections. To us it seems that at no time has it been more necessary to represent to the public the serious and practical side of electrical engineering, and we cannot see how that is to be done by the election of the chairman of a company, even though he be also a wealthy amateur. The Institution combines the theoretical and the practical, and it is quite immaterial from which branch the head is selected, so long as he is really and seriously engaged in the work of the profession. If the Institution were allied to societies whose objects are mainly those of research, there could be no objection whatever to the selection, but the Institution is engaged in scientific and practical work. In a sense it is an offshoot of the Institution of Civil Engineers, and it is to the example set by that body that attention should be given. In historical descriptions of that body will be found reference to the "distinguished men who have filled the presidential chair," and mention of the "illustrious roll of presidents and the record of their achievements." The distinguished men whose names are inscribed on the illustrious roll have been invariably engineers. A microscopical society, or a geographical society, even perhaps a photographic society, may be regarded as within the province of the amateur. Zoology is not a profession, and a wealthy student of animal life is more fitted than Mr. Jamrach to be the president of a zoological society; but the presidents of the Royal Academy, the College of Surgeons, or the Institution of Civil Engineers, are elected to their positions by reason of their eminence in the profession to which they have devoted themselves. We see no reason at all why electrical engineers should elect their president on a different system. The comparative newness of some branches of the profession has brought into the ranks of the Institution many men who are neither electricians nor engineers, and a certain amount of latitude must be expected in views; but we feel there cannot be much difference of opinion on the main point of principle, that the president of the Institution of Electrical Engineers should be not merely an electrical engineer, but an electrical engineer of eminence, commanding both the respect and confidence of the members.

It is possible that this view may have already presented itself to Sir David Salomons, and that the Council have been relieved from any difficulty by his intimating his inability to accept the post of President, an act which would be a graceful one, and fitly terminate the matter. In such a case, the Council would doubtless be able to put forward a nomination which would meet with unanimous approval, and avoid the necessity of an active ballot. If, however, the latter alternative has to be adopted, we hope that the members will exercise their franchise with intelligence, and accept the result with loyalty.

The passing over of a Council member in regard to the Presidential Chair is not an unknown thing in the annals of the Institution, and the Council, or members, cannot, therefore, argue that it is an unprecedented act, and if properly and judiciously done, it need not constitute a slur on the person passed over.

The Polarisation of Protoplasm.

THE frequent discovery of new and inexplicable electrical phenomena must force upon us the conviction that our knowledge of the science is still in its infancy, and defies the wildest imagination to predict what it may be two or three centuries hence. It has long been known that there is a close connection between electricity and some of the vital processes, but the relation is so complex, at least in the higher organisms, that we have not as yet been able to know much about. Dr. August Waller, in his remarkable experiments recently described in *Science Progress*, has, in investigating this subject, adopted the rational plan of trying the effect of the electric current on the simplest organisms. He tried the interesting experiment of sending an electric current through a bath in which living organisms were swimming about. When this was done in a bath containing paramœcia a strange thing happened. As soon as contact was made the whole crowd of paramœcia fell into order with their noses towards the cathode, and began to swim towards it in converging curves; while if the current were reversed the crowd broke up, all its units wheeled round and began to swim towards the new cathode. This, however, is not a general law for all micro-organisms, since some tend to swim against the current, and others to place themselves at right angles to it. If a current is sent through a bath containing a mixed crowd of ciliated and flagellated protozoa, they divide themselves into two distinct armies and march in opposite directions. A similar effect appears to be exercised by the electric current on more complex organisms. When the current was sent through a bath containing fresh tadpoles, the tadpole community appeared to lose its head, and became for a short time a writhing mass; but the disturbance soon subsided and the tadpoles emerged in good order, swimming quietly with their heads to the anode. The explanation of these extraordinary results will tax the combined powers of the physicist and the biologist. Do these organisms feel "uncomfortable" when the current passes through their bodies in certain directions? Or are their movements due to some intermediate electrolytic effect? The fact that they find oxygen at one side of their environment, and hydrogen at the other, may have something to do with determining their movements. Dr. Waller's success with the tadpoles would suggest that a similar experiment might with advantage be tried with a sufficiently powerful current in a public swimming bath. Experiments on the *genus homo* would settle by personal experience whether the down or the up potential gradient was the easier.

A Pioneer Traction Company.

WE presume the prospectus of the British Electric Traction (Pioneer) Company, Limited, which is published in another place, is a shadow of coming events. Although this company will no doubt exercise considerable influence on the future of electrical traction, it will be rather in a financial sense than otherwise. The prospectus does not help one very much as to what is the precise object of the company, except to float another one. Indeed, we shall not be far wrong if we consider the present company as a large syndicate. It is satisfactory to note, however, that in developing electric traction the company is not committed to any particular system. In view of the present state of electric traction it would not have been wise to have fettered itself with any single system, and, as far as we can learn, there will be no likelihood of the company running in concert with any particular manufacturer. The desire is to develop traction on the best lines and with the best means at hand, hence the success of this company should be of interest to every manufacturer. The Board is undoubtedly a strong one, and it is an important fact that Mr. Garcke is the managing director. Mr. Garcke has been closely concerned in the successful working of several electrical companies, and his special experience should be of immense use in developing electric traction on the right lines.

THE CARBORUNDUM PLANT AT NIAGARA.

The plant of the Carborundum Company, at Niagara Falls, which was started on Saturday, October 19th, may properly be considered, says the New York *Electrical World*, unequalled for concentrated power-consumption and novelty of product One thousand horse-power of electrical energy, generated by the great dynamos of the Niagara Power Company, were then turned into the reducing furnaces described below, and the manufacture on a large scale begun of carbide of silicon, known to commerce as carborundum, by the process invented by Mr. E. G. Acheson in 1891.

The various buildings and apartments of the carborundum plant are admirably arranged for the economical handling and manipulation of the materials. The stock building, into which are received the crude materials, is provided with a railway track connecting with the Niagara Junction Railway, on which the loaded cars are conveyed to the various bins or compartments provided for the reception of the crude materials, which consist of coke from the Pennsylvania bituminous coal fields, white sand from Ohio, salt from Syracuse, and sawdust from the mills of Tonawanda. Conveniently arranged in relation to the storage bins of crude materials is a most complete grinding, grading and mixing plant, into which the coke, as it comes from the cars, is introduced and ground and sifted into assorted sized grains and conveyed into bins; from the latter it is drawn and mixed, in proper proportions, with measured quantities of sand, salt, and sawdust, and then delivered into a bin provided for the finished mixture. The work is done by automatic machinery at the least expenditure of manual labour.

The four crude materials having been thus thoroughly mixed, the product is conveyed to the electrical furnaces, situated in an adjoining building, and which have the appearance of rough and apparently crude oblong brick boxes, made without cement, mortar, or other binding materials. Provision is made for five of these boxes, which extend down one side of the large spacious building, each of them measuring about 15 feet in length by 7 feet in width, and the same in height. In the centre of each end is placed a large bronze plate, and these are connected by means of four large copper cables to massive copper bars extending under the floor at either end of the furnaces. Connecting with the inner surfaces of the bronze plates are 120 carbon rods, 60 to each plate. These carbon rods are 3 inches in diameter and something over 2 feet in length, and are so placed as to pass through the end walls of the brick box or furnace, projecting into the interior and toward each other, thus constituting the terminals. Into this rectangular brick box the mixture that has been prepared in the stock room is introduced, about 10 tons constituting a charge, and through the centre of the mass of mixed materials is placed a core or cylinder of granules of crushed coke extending from the carbon rods at one end of the furnace to those at the other end, a perfect electrical connection through the furnace, by means of the bronze plates, carbon rods and the core being thus made.

The furnace, as now described, is prepared for the turning on of the electrical current, and this is provided for and controlled in the adjoining building, which was specially constructed for the transforming apparatus used in reducing the high pressure current as received from the dynamos of the Niagara Power Company to the low pressure current used in the electric furnaces. Located in the same building is the regulating apparatus used in controlling the current as it passes to the furnaces. The transformer and regulator contained in this building are said to be the largest that have ever been built, and the regulator absolutely controlling a current of 1,000 H.P.

When everything has been properly prepared current is turned into the granular core, already referred to, and kept on for 24 consecutive hours. All of the vast amount of energy being transmitted to the core—21 inches in diameter and about 9 feet long—and within its mass, it is converted or transformed from electrical to heat energy.

A short time, perhaps two hours, after the turning on of the current, gases begin to escape through the crevices of the brick walls of the furnace, and, being ignited, burn with a lambent blue flame. As the process continues, the outer walls and top of the mass in the furnace slowly rises in temperature through the transmission of the intense heat from the core, the entire top of the mass being red-hot in about 12 hours. After the current has remained on for the period of 24 hours, or until such time as the workman in charge recognises as sufficient, it is switched off in the transformer building, the flexible cables are disconnected from the bronze plates, and others are connected with the plates of the next furnace in the series of five, which in turn are carried through the same operation.

One end of the first furnace is then removed, and a cross-section through its centre exposed, thus permitting of a ready inspection of the results of the operation. In the centre is the granular core, in the same position in which it was originally placed, but it is now purified of all foreign substances. It is now pure carbon, and has lost about one-fourth of its weight; this loss represents the volatilised impurities. The presence of grains of graphite disseminated throughout its mass indicate that its temperature must have been near 7,000° F.—the point of graphitic formation. Surrounding the core in the form of a cylinder is a beautiful crystalline formation, the crystals being constructed on lines radiating from the centre. The crystals in immediate contact with the core are looped or built together into one concrete mass; as the distance from the core is increased, the size of the crystals diminishes rapidly, until at about 15 inches all crystallisation ceases and an amorphous material is encountered, of a whitish gray colour, for a distance of 2 inches, when a sudden change occurs to a black mass composed of the original mixture, now held together in a cemented state by the fusion of the salt.

The crystalline and amorphous material, lying between the core and the outer black mass, is carbide of silicon, being composed of equal atoms of carbon and silicon. About 2 tons of carborundum is produced in one furnace run, and to prepare it for the market it is first passed under heavy iron rolls for the purpose of crushing apart and separating the individual crystals, after which it is treated with an acid and water bath to remove solubles. It is then dried and sifted, to separate the various sizes.

Referring to the value of carborundum as an abrasive, Mr. George F. Kunz, of the firm of Tiffany & Co., of New York, in an article in the *American Journal of Science* for December, 1893, states that he found that it would readily scratch red, blue, white, pink, and yellow corundum in the form of fine gems, showing it to be an artificial substance that exceeds all natural substances except the diamond in hardness.

Owing to the limited facilities heretofore existing, the production of carborundum has been so small—not over 300 lbs. per day—as to practically restrict its uses to the finer trades, such as the dental and manufacturing jewellers' trades, fine tool grinding, pearl grinding, and kindred industries. The development in the dental trade especially has been remarkable, and in the form of discs, lathe and engine wheels, and cloth-finishing strips, carborundum is rapidly displacing all other abrasive substances in this important industry, not only in the United States but throughout Europe.

THE HISTORY OF A GREAT ELECTRICAL COMPANY.

The Allgemeine Elektricitäts-Gesellschaft, Berlin, is probably the largest electrical manufacturing company in Europe, and the second largest in the world. Some interesting information concerning the past history and future projects of this company was obtained by our representative in a recent interview with Herr Rathenau, its distinguisned director-in-chief.

The company was started some 12 years ago to acquire and work the patent rights in Germany of the Edison incandescent lamp. The total capital now invested in its multifarious undertakings is about £7,500,000. The three principal sub-companies are the Central Bureau, or A. G., Berlin, which includes the factory, and has a capital of £1,650,000; the Berlin Electrical Works, which supplies light and power to the city of Berlin, and has a capital of £1,000,000; and the General Local and Street Railway

Company, Berlin, which has a capital of £500,000. Among other undertakings of the company may be mentioned the aluminium works at Neuhausen, with a capital of £500,000; the power station at the Rhine Falls, producing 16,000 H.P.; lighting installations at Barcelona and Genoa; and the Leipzig street railways, with a capital of £300,000.

The 100-mark shares in the A. G. and in the Berlin Electrical Works stand at present at 250, and the shares in all the companies are fully paid up; a condition of financial prosperity which the electrical supply companies of the United Kingdom may envy. One of the golden rules of the A. G. is that patent rights are never paid out of capital.

A short history of the formation and growth of a company which has successfully carried out such large undertakings in the supply of electric light and power will be interesting, in view of the coming production and distribution of electrical energy on the grand scale all over the civilised world. The electric lighting of Berlin has been declared, by no less an authority than Edison, to be the best in the world, and deserves therefore to be studied as a model for the lighting of large cities.

The Allgemeine Elektricitäts-Gesellschaft is one of the widely ramifying industrial undertakings which resulted from the introduction of the incandescent lamp by Edison. The Edison Electric Light Company, of Europe, was formed to work Edison's invention in Europe, and out of this company came two sub-companies, one of which acquired the patent rights for England, and the other for the Continent. The latter company, named the Compagnie Continentale, had its seat in Paris.

Herr Emil Rathenau, who must be looked upon as the founder of the Allgemeine Elektricitäts-Gesellschaft, was at this time unsuccessfully negotiating with Siemens & Halske for the lighting of the Leipziger Strasse in Berlin. On hearing of Edison's invention, he determined to investigate it, and if satisfactory, to acquire the patent rights for Germany. With this object he visited the Paris Exhibition of 1881, and being satisfied that the incandescent lamp had a future before it, he formed a syndicate to test the invention, and promote its introduction in Germany. Some small installations were carried out in clubs and printing establishments in Berlin, and two theatres were lighted at Munich, all of which experiments proved very successful. The syndicate was now converted into a larger undertaking, named the German Edison Company, with a capital of £250,000.

The founders of the German Edison Company had aimed from the first at supplying electric light on a large scale from central stations, consequently they started by entering into negotiations with the municipality of Berlin, to light a part of the city from a central electric generating station. An agreement was signed, by which a concession was granted to the German Edison Company to light a certain district. It was considered desirable to form a separate company to carry out this work, and hence arose the Berlin Electrical Works (Die Berliner Elektricitäts Werke). After a short separate existence, this company was finally, in August, 1887, taken over by the German Edison Company.

At first, two central stations were erected, one in Markengrafstrasse, and another later, and on a smaller scale, in Mauerstrasse. The Markengrafstrasse station started with three engines of 150 H.P. each, and was mainly intended for the lighting of theatres; in the same place another generating plant of the same was afterwards erected, and, finally, the engines in both were taken out and replaced by six engines, 400 H.P. each, and directly coupled to the dynamos. The direct-coupling of engines to the dynamos was found to lead to a considerable increase in economy. The Mauerstrasse station started with three engines of 100 H.P., and three of 150 H.P., which were afterwards replaced by two engines of 400 H.P. and three of 1,200 H.P. each, directly coupled.

A third station erected at the Schiffbauerdamm has three engines of 1,200 H.P. each, and a fourth station at Spanduerstrasse is fitted with the same engine power. The new orders for this year are for three engines of 2,000 H.P. each.

There are 900 kilometres of cable for lighting in Berlin, and all the networks of the separate stations are connected together, an arrangement which is found to add considerably to the steadiness of the supply.

The agreement between the Allgemeine Elektricitäts Gesellschaft (Berlin Electrical Works) and the Municipality of Berlin, under which the company has been so successfully developed, is well worth consideration as a model for similar undertakings. The present agreement is altered only in a few particulars from the original agreement made with the company when known as the German Edison Company. The original agreement was by no means too favourable to the interests of the company, as may be judged from the following conditions:—

1. The company obtains the right to lay conductors in the streets of the city, but no exclusive right.

2. In consideration, the company has to pay 10 per cent. of the gross income as a tax to the city, and, further, a quarter of the net profit over 6 per cent.; further, to supply the municipality with light on certain favourable terms.

3. The municipality reserves to itself the right of acquiring the property under certain favourable terms.

4. The work has to be carried out under certain prescribed limits of time and space. Pledges have to be given for the continuous maintenance of the plant in good working order. Questions of compensation for damage have to be decided by a magistrate.

In the new agreement, the supply of house fittings is thrown open to competition. The 10 per cent. tax was remitted for some time from the starting of new central stations.

In the next article we shall give Herr Rathenau's views on the future of electric supply on the grand scale.

(*To be continued.*)

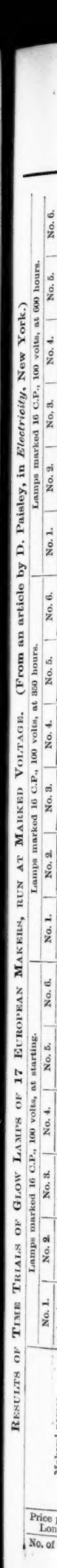
EUROPEAN INCANDESCENT LAMPS.

[COMMUNICATED.]

The results of a life test of a very practical nature have lately been published by Mr. D. Paisley, in *Electricity*, New York. In a recent issue you refer to certain points connected with this trial, and in particular notice the behaviour of the Ediswan and the Robertson lamps. No reference, however, is made to the large number of lamps of continental make which were also tested; and as some of them are now used in considerable quantities in England you may deem it of interest to publish a description of their behaviour.

The plan adopted in the trial was to buy "over the counter" six 100-volt 16-C.P. lamps, and six of 100-volt 8-C.P., from a number of different European manufacturers. These lamps were then run at the *marked* voltage, and photometric readings of each individual lamp were taken once a week. The price paid for the lamps was also noted. The lamps being thus in no way specially selected naturally varied to some extent in incandescence, not only in the respective lots but still more, some of them, when the several makers are compared. Thus some at the start were running at over 5 watts to the candle, whilst others were consuming less than 3 watts per candle. The trial cannot, therefore, be held to indicate very precisely which is the best make of lamp when all considerations are taken into account, but it *does show very accurately* what consumers, who are supplied with current from central stations, get when buying their lamps from these particular makers.

A table is given of readings of each respective lamp at the commencement of the test, at the end of 350 hours, and at 600 hours. As it takes a certain amount of study to intelligibly follow and grasp the features and deductions to be drawn from this table, the average candle-power and energy consumed by the lamps of each maker, has been calculated for the benefit of those who do not care to make a minute study. It will be noticed that the 16-C.P. lamps of three makers remain at less than 4 watts per candle after a run of 600 hours—the Daylight, Gabriel & Angenault, and Robertson; whilst the Phaeton, Pope & Goosens, and Siemens & Halske's lamps follow at no great distance. The lamps which commence at comparatively low incandescence undergo, mostly, but a slight change in candle-power and efficiency, the best of these being, according to these figures, undoubtedly those of the Edison & Swan Company. The Sunbeam lamps, which are exceptional, probably lose candle-power owing to rather severe blackening. It may be observed that some lamps, notably the Daylight, the Hard, and one or two


Results of Time Trials of Glow Lamps of 17 European Makers, run at Marked Voltage. (From an article by D. Paisley, in Electricity, New York.)
Lamps marked 16 C.P., 100 volts, at 600 hours.
No. 1. No. 2. No. 3. No. 4. No. 5. No. 6.
Lamps marked 16 C.P., 100 volts, at 350 hours.
No. 1. No. 2. No. 3. No. 4. No. 5. No. 6.
Lamps marked 16 C.P., 100 volts, at starting.
No. 1. No. 2. No. 3. No. 4. No. 5. No. 6.
Price
Lon
No. of

Results of Time Trials of Glow Lamps of 17 European Makers, run at Marked Voltage. (From an article by D. Paisley, in *Electricity*, New York.)

No. of Maker.	Price paid in London.	Makers' names.	Lamps marked 16 C.P., 100 volts, at starting.																															
			No. 1.			No. 2.			No. 3.			No. 4.			No. 5.			No. 6.			Lamps marked 16 C.P., 100 volts, at 350 hours.															
																				No. 1.			No. 2.			No. 3.			No. 4.			No. 5.			No. 6.		
			Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.
1	25c.	Allgemeine Co., Berlin ..	·67	14½	4·65	·65	13	5·00	·65	14	4·65	·65	13	5·10	·62	13½	4·60	·65	16	4·05	·69	16½	4·14	·68	14	4·87	·66	14	4·72	·70	16	4·40	·63	13½	4·67	·68	16½	4·40
2	25c.	Brush Company, Vienna ..	·51	11	4·65	·52	13	4·00	·50	11½	4·30	·53	11½	4·60	·54	11½	4·70	·51	13	3·90	·52	11½	4·63	·54	12½	4·25	·52	11	4·72	·54	12½	4·40	·56	12½	4·58	·52	13½	3·86
3	15c.	Constantia, Venloo	·51	17	2·98	·51	16	3·18	·51	19	2·68	·51	16	3·10	·51	16½	3·08	·51	18½	2·71	·53	15½	3·37	·54	15	3·60	..	1*	..	·54	15	3·60	·53	15	3·54	..	2*	..
4	24c.	Daylight	·47	12½	3·76	·49	14	3·50	·49	14½	3·44	·48	11½	4·15	·48	12½	3·75	·50	16	3·12	..	3*	..	·53	15½	3·46	·53	15½	3·43	·51	13	3·93	·52	15½	3·41	·55	17	3·24
5	26c.	Fleischhaker & Co., Sweden	·55	18¾	2·93	·58	18	3·22	·70	24	2·90	·64	14	4·55	·54	15½	3·46	·54	13½	4·00	..	4*	..	..	5*	..	..	6*	..	·67	14	4·80	..	7*	..	·55	12¾	4·32
6	25c.	Gabriel & Angenault, Paris	·50	17	2·99	·44	12½	3·50	·49	16	3·04	·52	19	2·72	·49	16	3·04	·49	15½	3·14	·50	14½	3·46	·44	10¾	4·10	·49	13½	3·63	·52	15½	3·36	..	8*	..	·49	13½	3·64
7	20c.	Hard, Zürich	·51	11½	4·44	·52	13½	3·86	·51	11½	4·42	·51	14½	3·50	·52	14	3·07	·54	14½	3·77	·52	14½	4·16	·58	15½	3·75	·54	12½	4·25	·53	14½	3·72	·54	14½	3·73	·59	15½	3·82
8	18c.	Phaeton	·67	15	3·80	·53	17½	2·98	·72	15½	4·65	·70	22	3·18	·72	21	3·42	·72	18½	3·90	·58	14	4·15	..	9*	..	·75	14½	5·10	..	10*	..	·73	18½	3·96	·74	18¾	3·96
9	25c.	Gebruder Pintsch, Berlin ..	·56	17	3·28	·60	19	3·14	·60	19	3·14	·61	19½	3·14	·58	16½	3·50	·62	19¾	3·13	·59	15½	3·76	·64	16½	3·90	·63	17	3·72	·64	17½	3·67	·60	15½	3·94	·66	17¾	3·74
10	19c.	Pope & Goosens, Venloo ..	·52	14½	3·64	·55	16½	3·38	·53	15	3·50	·51	14	3·63	·51	12¾	4·00	·54	15½	3·47	·57	15	3·81	·58	15	3·88	·57	14½	3·91	·55	14	4·00	·58	15	3·88	·58	16	3·64
11	28c.	Robertson, London	·57	14½	3·94	·55	16	3·42	·57	16	3·55	·56	14	3·98	·54	13	4·15	·55	15½	3·54	·58	14½	4·00	·56	16	3·50	·58	15½	3·81	·58	14½	4·00	·57	13½	4·30	·56	15½	3·68
12	25c.	Siemens & Halske, Berlin ..	·59	17½	3·35	·56	13	4·30	·55	14½	3·84	·59	15	3·96	·60	16	3·75	·52	15	3·45	·61	17½	3·50	·58	13½	4·30	·58	15¾	3·50	·58	14	4·25	·58	16½	3·53	·54	15¾	3·44
13	27c.	Sunbeam Co., Gateshead ..	·65	18½	3·59	·62	18	3·44	·61	12½	4·90	·55	9½	5·75	·62	16	3·83	·65	19	3·38	·69	12¾	5·42	·65	12¾	5·10	·61	11¼	4·52	·60	10	6·00	·64	11½	5·70	·69	11½	6·00
14	16c.	Sturm & Co., Vienna ..	·35	12½	4·37	·55	10	5·50	·55	12½	4·37	·54	11¾	4·60	·54	11¾	4·60	·53	11¾	4·60	·62	15	4·15	·56	8	7·00	·58	12½	4·65	·57	11¾	4·35	·60	13¾	4·40	·61	14¼	4·30
15	23c.	Stearn, Zürich	·54	17	3·16	·52	14¾	3·60	·53	14¾	3·60	·50	13¾	3·62	·50	14	3·57	·54	16	3·36	·54	12¾	4·25	·53	13¾	3·85	·53	13¼	4·00	·52	12¾	4·10	·51	12¼	4·15	·55	13¼	4·08
16	25c.	Svea Company, Sweden ..	·53	15½	3·44	·51	17½	2·90	·51	15½	3·28	·50	15½	3·22	·50	15½	3·25	·50	15½	3·22	·53	10½	5·05	·51	12¼	4·10	·52	9¾	5·32	·50	12	4·16	..	11*	..	·48	8¾	5·46
17	30c.	Edison and Swan (Old manufacture..	·62	16½	3·83	·60	16½	3·65	·62	16	3·83	·58	15¾	3·70	·60	15½	3·89	·60	15¾	3·89	·63	15¾	4·00	·60	15¾	3·83	·62	15½	4·00	·59	15	3·95	·61	15	4·03	·60	15½	3·95
8	30c.	Edison and Swan (New manufacture	·56	14¾	3·80	·56	14¾	3·80	·56	15¼	3·63	·56	14¾	3·80	·56	14¾	3·80	·56	15	3·74	·57	14¼	3·95	·57	14	4·08	·57	15	3·80	·58	15	3·88	·56	14¼	3·94	..	19*	..

No. of Maker.	Price paid in London.	Makers' names.	Lamps marked 16 C.P., 100 volts, at 600 hours.																															
			No. 1.			No. 2.			No. 3.			No. 4.			No. 5.			No. 6.																	
			Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.
1	25c.	Allgemeine Co., Berlin ..	·69	15	4·60	·67	13	5·30	·67	13½	4·87	·70	15½	4·54	·63	13	4·85	·66	15	4·40																
2	25c.	Brush Company, Vienna ..	·52	10½	4·82	·54	12½	4·33	·52	11½	4·63	·54	12	4·50	·56	12	4·65	·52	13	4·00																
3	15c.	Constantia, Venloo	..	13*	..	·54	13½	3·94	..	1*	..	..	14*	..	..	15*	..	..	2*	..																
4	24c.	Daylight	..	3*	..	·53	14½	3·68	·52	14¾	3·53	·52	13	4·00	·53	14½	3·72	·55	15	3·68																
5	26c.	Fleischhaker & Co., Sweden	..	7*	..	·55	12¾	4·32	..	4*	..	..	5*	..	..	6*	..	·66	13½	4·90	..	7*	..	·55	12	4·60										
6	25c.	Gabriel & Angenault, Paris	·45	11	4·10	·49	12½	3·92	·52	14½	3·60	..	8*	..	·49	12½	3·92	·52	14½	3·60	..	8*	..	·49	12½	3·92										
7	20c.	Hard, Zürich	·58	15	3·38	·55	12¼	4·40	·53	13½	3·92	·55	13¾	4·00	·60	15	4·00	·52	12	4·33	·58	15	3·38	·55	12¼	4·40	·53	13½	3·92	·55	13¾	4·00	·60	15	4·00
8	18c.	Phaeton	·58	14	4·15	..	9*	..	·75	14	5·36	..	10*	..	·72	14½	5·00	..	16*	..																
9	25c.	Gebruder Pintsch, Berlin ..	·62	14¼	4·30	·60	14½	4·22	·62	14	4·44	·58	12	4·85	·64	15	4·28																			
10	19c.	Pope & Goosens, Venloo ..	·57	13¾	4·15	·57	13¾	4·14	·55	13½	4·07	·57	13¾	4·15	·57	14½	3·94																			
11	28c.	Robertson, London	·56	16¾	3·80	·58	15½	3·75	·58	14½	4·00	·57	13½	4·30	·56	15½	3·68	·58	14½	4·00																
12	25c.	Siemens & Halske, Berlin ..	·57	12¾	4·50	·57	14	4·10	·55	10¾	5·10	·49	7½	6·72	·53	13¾	3·86																			
13	27c.	Sunbeam Co., Gateshead ..	·64	11	6·80	·61	10½	5·95	·60	9½	6·47	·64	10	6·40	·68	10½	6·47																			
14	16c.	Sturm & Co., Vienna ..	..	8	7·00	·58	12¾	4·55	·57	12	4·75	6*	13½	4·45	·61	13½	4·54																			
15	23c.	Stearn, Zürich	·53	12½	4·25	·53	12½	4·25	·52	11¼	4·50	·50	11½	4·35	·54	12	6·50																			
16	25c.	Svea Company, Sweden ..	·48	8¾	5·46	·53	9½	5·57	·50	10½	4·77	·51	7½	6·83	·50	10	5·00	..	11*	..	·48	7¾	6·16													
17	30c.	Edison and Swan (Old manufacture..	·59	15	3·95	·61	15	4·03	·60	15½	3·95	·66	14¾	4·70	·63	14¾	4·34	·65	14½	4·49	·64	14	4·57	·64	14¾	4·49	·63	14	4·50							
8	30c.	Edison and Swan (New manufacture	·58	15	3·88	·56	14¼	3·94	..	19*	..	·60	13	4·61	·63	14	4·29	·60	14¾	4·07	·59	13	4·54	·59	14	4·21	..	13*	..							

Remarks on Such Lamps.—1*, burnt out at 179 hours; 2*, burnt out at 250 hours; 3*, burnt out at 73 hours; 4*, burnt out at 244 hours; 5*, burnt out at 116 hours; 6*, burnt out at 300 hours; 7*, burnt out at 290 hours; 8*, burnt out at 245 hours; 9*, burnt out at 320 hours; 10*, burnt out at 275 hours; 11*, burnt at 199 hours; 12*, burnt out at 263 hours; 13*, burnt out at 550 honrs; 14*, sealing point broken at 513 hours; 15*, burnt out at 484 hours; 16*, burnt out at 586 hours; 17*, burnt out at 405 hours.

Results of Time Trials of Glow Lamps of 15 European Makers, run at Marked Voltage.

No. of Maker.	Price paid in London.	Makers' names.	Lamps marked 8 C.P., 100 volts, at starting.																															
			No. 1.			No. 2.			No. 3.			No. 4.			No. 5.			No. 6.			Lamps marked 8 C.P., 100 volts, at 350 hours.															
																				No. 1.			No. 2.			No. 3.			No. 4.			No. 5.			No. 6.		
			Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.
1	25c.	Allgemeine Company ..	·30	8¾	3·43	·29	9¼	3·25	·30	8	3·75	·25	7	3·57	·28	8	3·50	·25	7½	3·33	·37	6¾	5·45	·27	6¼	4·30	·31	8	3·88	·26	6½	4·15	·30	7½	4·00	·28	6½	4·30
2	25c.	Brush Company, Vienna ..	·29	8	3·64	·33	9½	3·50	·29	7	4·14	·33	8½	3·87	·30	8	3·75	·30	9	3·33	·27	6½	4·15	·33	9	3·66	·29	7	4·14	·34	8¼	4·12	..	1†	..	·32	8¼	3·76
3	15c.	Constantia, Venloo	·29	9¼	3·12	·27	8½	3·18	·29	7	4·14	·28	9	3·11	·27	9	3·00	·26	9½	2·73	..	2†	..	·29	7¾	4·00	·30	6¾	4·43	..	3†	..	·29	7¾	3·73	·29	7¾	3·73
4	24c.	Daylight	·29	5¾	5·05	·30	6¼	4·80	·33	8¾	3·77	·32	9	3·55	·30	7	4·28	·30	10½	2·92	·34	8¾	3·87	·32	8¾	5·55	·34	8½	4·00	·33	8¾	3·77	·31	6½	4·76	·33	8¾	3·77
5	16c.	Fleischhaker & Co., Sweden	·41	14½	2·82	·38	9	4·20	·37	8	4·62	·40	12	3·33	·39	8¾	4·46	·35	10½	3·40	·37	8	4·62	..	4†	..	·39	8	4·85	..	5†	..	..	6†	..	·38	8½	4·60
6	25c.	Gabriel & Angenault, Paris	·34	12	2·84	·33	10½	3·15	·31	7¾	4·00	·32	10	3·20	·30	10	3·00	·30	10	3·00	·31	7¾	4·26	·31	8¾	3·75	·32	7¾	4·12	·33	9½	3·56	·33	9¾	3·47	·33	8¾	3·77
7	20c.	Hard, Zürich	·32	6½	4·90	·30	5½	5·50	·30	8	3·75	·31	7	4·43	·29	8	3·62	·28	8	3·50	..	7†	..	·31	8½	4·10	·32	7¾	4·12	·32	6½	4·90	·33	7	4·70	·31	6½	4·75
8	18c.	Phaeton Company	·40	8	5·00	·40	9	4·45	·26	4⅜	6·22	·36	6	6·00	·35	7⅛	4·67	·35	7	5·00	·47	9	5·20	·40	6¼	6·35	·38	5¼	7·23	·37	5½	6·70	·38	6	6·30	·38	5½	6·90
9	25c.	Gebruder Pintsch, Berlin ..	·35	10	3·50	·36	12	3·00	·35	10⅜	3·25	·34	8¾	3·10	·33	10	3·30	·34	9	3·77	·36	9¾	3·88	·36	9¼	3·88	·38	10¼	3·10	·36	8¼	4·35	·37	9¾	3·90	..	8†	..
10	19c.	Pope & Goosens, Venloo ..	·30	7	4·30	·30	7	4·30	·33	7½	4·44	·34	9	3·77	·30	8	3·75	·30	9	3·33	·32	6¾	4·72	·33	8¼	4·00	·33	7½	4·90	·36	8½	4·23	·33	7½	4·90	·32	8¼	3·87
11	28c.	Robertson, London	·32	7	4·60	·35	9¾	3·58	·36	8	4·50	·33	8¾	3·10	·33	8	4·12	·33	10½	3·22	·35	7½	4·65	·30	7½	4·00	·36	7¾	4·63	·35	7½	4·90	..	9†	..	·36	9½	3·88
12	25c.	Siemens & Halske, Berlin..	·38	13	2·92	·38	11	3·46	·37	8	4·62	·32	8	4·00	·33	9	3·66	·34	9½	3·67	·38	10	3·80	·37	6¾	5·45	·37	7¾	4·75	·37	7½	4·95	·35	8¼	4·23	·36	7¾	4·62
13	27c.	Sunbeam Co., Gateshead ..	·40	7½	5·20	·40	8½	4·94	·40	8	5·00	·38	9	4·22	·36	7¾	4·64	·37	9	4·11	·40	8¼	4·83	·41	8¼	4·95	·41	7¾	5·26	·42	8¾	4·93	·40	7	5·70	·41	8¼	4·95
14	23c.	Stearn, Zurich	·34	10½	3·25	·34	10½	3·25	·32	9½	3·60	·30	10¼	2·92	·30	9	3·33	·30	9½	3·15	·34	8½	4·00	·33	8¾	3·77	·34	9¼	3·67	·33	9¾	3·38	·35	8¼	4·10	·33	8	4·12
15	30c.	Edison and Swan (Old manufacture..	·41	9	4·55	·40	8	5·00	·41	9¼	4·42	·40	7¾	5·50	·42	10	4·20	·39	7½	5·20	·42	9	4·66	·39	7¼	5·35	·41	8¾	4·80	·39	7¾	5·35	·41	9	4·55	·40	7¾	5·50
16	30c.	Edison and Swan (New manufacture.	·37	7¼	5·10	·38	8¼	4·47	·37	7¼	5·10	·37	7¼	5·10	·37	7⅜	4·90	·38	7¼	5·05	·37	7¼	5·10	..	10†	..	·37	7¼	5·10	·37	7¼	5·10	·37	7	5·07	..	15†	..

No. of Maker.	Price paid in London.	Makers' names.	Lamps marked 8 C.P., 100 volts, at 600 hours.																															
			No. 1.			No. 2.			No. 3.			No. 4.			No. 5.			No. 6.																	
			Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.	Amperes.	Candle-power.	Watts per C.P.
1	25c.	Allgemeine Company ..	·26	5⅜	4·52	·27	5½	4·90	·30	7	4·30	·24	5½	4·57	·29	6½	4·45	·28	5⅜	4·85																
2	25c.	Brush Company, Vienna ..	·27	6½	4·30	·32	8	4·00	·29	6⅜	4·28	·33	7½	4·54	..	1†	..	·32	8½	3·76																
3	15c.	Constantia, Venloo	..	2†	..	..	11†	..	·29	6½	4·45	..	3†	..	·29	7	4·14	·28	7	4·00																
4	24c.	Daylight	·33	7½	4·25	·32	6¼	5·10	·34	7	4·85	·33	7⅜	4·25	·32	6¼	5·10	·33	7½	4·25																
5	16c.	Fleischhaker & Co., Sweden	·36	7⅜	4·62	..	4†	..	..	12†	..	..	5†	..	..	6†	..	·37	8	4·62																
6	25c.	Gabriel & Angenault, Paris	·30	7	4·26	·31	7⅜	4·13	·32	7¼	4·40	·32	8	4·00	·33	8	4·11	·32	7⅜	4·11																
7	20c.	Hard, Zürich	..	7†	..	·35	7⅜	4·50	·32	7⅜	4·12	·32	6½	4·80	·33	6½	5·07	·30	6½	4·60																
8	18c.	Phaeton Company	·47	7½	5·45	·39	6	6·47	·38	5¼	7·20	·37	5	7·40	·38	5½	6·90	·38	5	7·60																
9	25c.	Gebruder Pintsch, Berlin ..	·34	7½	4·52	·34	7⅜	4·52	·32	7⅜	4·53	·34	6⅜	5·00	·37	8	4·60	..	8†	..																
10	19c.	Pope & Goosens, Venloo ..	·32	6½	5·10	·32	7⅜	4·25	·32	7	4·56	·34	7⅜	4·36	·32	7	4·55	·32	7⅛	4·25																
11	28c.	Robertson, London	·34	7½	4·67	·30	6⅜	4·42	·35	7⅜	4·50	·37	7½	5·07	..	9†	..	·35	8½	4·10																
12	25c.	Siemens & Halske, Berlin..	·38	8½	4·45	·35	6½	5·36	·36	6⅜	5·30	·34	7	4·85	..	13†	..	·36	7½	4·95																
13	27c.	Sunbeam Co., Gateshead ..	·40	7½	6·30	·41	7⅜	5·45	·40	7	5·70	·41	7⅜	5·26	·40	7	5·70	·43	7½	5·30																
14	23c.	Stearn, Zurich	·33	7½	4·54	·33	7⅜	4·25	..	14†	..	·33	7½	4·40	·33	7⅜	4·54	·33	7½	4·40																
15	30c.	Edison and Swan (Old manufacture..	·45	8½	5·30	·42	9	4·66	·44	8	5·50	·41	7	5·85	·44	8½	5·18	·42	7	6·00																
16	30c.	Edison and Swan (New manufacture.	·40	7	5·71	..	10†	..	·40	7	5·71	·38	7	5·43	·39	6⅜	6·00	..	15†	..																

Marked Voltage Remarks on such Lamps.—1†, burnt out at 197 hours; 2†, burnt out at 266 hours; 3†, burnt out at 198 hours; 4†, burnt out at 151 hours; 5†, burnt out at 151 hours; 6†, burnt out at 267 hours; 7†, burnt out at 289 hours; 8†, burnt out at 344 hours; 9†, burnt out at 341 hours; 10†, broken when testing vacuum at 350 hours; 11†, burnt out at 445 hours; 12†, burnt out at 433 hours; 13†, burnt out at 440 hours; 14†, detached from collar at 574 hours; 15†, burnt out at 295 hours.

others, exhibit the not altogether undesirable property of increasing appreciably in candle-power on running. This is doubtless owing to an exceptional fall in the resistance of the carbons. An increase in current in fact may be noticed in almost every lamp at the 350 hour stage.

Turning to the 8-C.P. lamps it will be seen that the characteristic features noticeable in the several makes of 16-C.P. lamps are by no means always preserved. The average incandescence of the 8-C.P. lamps is, as a rule, below that of the 16-C.P. lamps at the start, and decidedly so at the close. The Allgemeine Company and the Brush Company lamps are exceptional. Gabriel and Angenault lamps come out very well, and the Constantia show well too, but the Phaeton, the Daylight, and the Robertson do not hold the same high place as amongst the 16-C.P. lamps. The Sunbeam 8-C.P. lamps show a slight improvement over those of 16-C.P., but the Ediswan, both Old and New, are markedly inferior—probably from heavy blackening, for the current

TABLE SHOWING THE AVERAGE CANDLE-POWER AND WATTS PER CANDLE OF 16-C.P. LAMPS

	Commencement.			350 hours.			600 hours.		
	A.	C.P.	Watts.	A.	C.P.	Watts.	A.	C.P.	Watts.
Allgemeine... ...	·65	14	4·66	·67	15·2	4·54	65	14·21	4·76
Brush Co., Vienna...	·52	11·9	4·36	·53	12·1	4·41	·53	11·87	4·50
Constantia... ...	·51	17·25	2·95	·53	15·19	3·55	...	...	...
Daylight	·48	13·50	3·62	·53	15 20	3 49	53	14·30	3·72
Fleischhaker & Co...	·59	17·29	3 51	...	...	...	...	...	...
Gabriel & Angenault	·47	16	3·07	·48	13·55	3 64	·49	12·40	3·83
Hard	·52	13 21	3 84	·55	14·46	4·07	·57	13·62	4·14
Phaeton	·66	18·29	3·65	·70	14 37	3 90	·68	13·60	4·00
Gebruder & Pintsch	·59	18·37	3·22	·64	16 62	3·79	61	13 90	4·37
Pope & Goosens ...	·526	14·54	3·60	·57	14 90	3 86	·57	13·87	4·08
Robertson	·56	14·80	3 76	·57	14·70	3·89	·57	14·80	3·93
Siemens & Halske...	·57	15·10	3 82	·57	15·50	3·75	·55	12·10	4·05
Sunbeam Co. ...	·62	15·60	4·14	·64	11·60	5·45	·64	10·46	6·29
Sturm & Co. ...	·54	11 66	4 34	·57	12·54	4·80	·58	11·95	5 06
Stearn	·52	15·00	3·48	·53	13 04	4·07	·52	11·83	4·77
Svea & Co.	·51	15·79	3·22	·51	10·70	4·82	·50	9·05	5·66
Ediswan, Old ...	·60	15·83	3·79	·61	15 37	3 82	·64	14·29	4 35
Ediswan, New ...	·56	14·9	3·88	·57	14 55	3·93	·59	13·75	4·22

TABLE SHOWING THE AVERAGE CANDLE-POWER AND WATTS PER CANDLE OF 8-C P. LAMPS.

	Commencement.			350 hours.			600 hours.		
	A.	C.P.	Watts.	A.	C.P.	Watts.	A.	C.P.	Watts.
Allgemeine Co. ...	·28	8	3·47	·29	6 8	4·30	·27	5·9	4·59
Brush Co., Vienna...	·31	8·25	3·69	·30	7 9	3 95	·30	7·3	4 20
Constantia	·27	8 6	3 43	·29	7·4	3·89	29	7	4·19
Daylight	·30	8	4·14	·33*	7·9	4·29	·33	7 1	4·60
Fleischhaker & Co.	·38	10·4	3·73	·38	8	4·68	...	...	...
Gabriel & Angenault	·32	10	3·19	·32	8½	3·82	·31	7·6	4·08
Hard	·30	7·1	4·28	·31	7·2	4·51	·32	7	4·61
Phaeton	·37	7·2	5·22	·39	6·2	6·41	·39	5·6	6·83
Gebruder & Pintsch	·34	10·1	3·29	·36	9·2	3·82	·33	7·5	4·63
Pope & Goosens ...	·31	7 9	3·98	·33	7·7	4·45	·32	7	4·51
Robertson	·33	8 5	3 85	·34	7·9	4·41	·34	7·5	4·7
Siemens & Halske...	·35	9·7	3·72	·36	7·9	4·63	·36	7·2	4·98
Sunbeam Co. ...	·38	8·3	4 68	·41	8	5·12	·41	7 3	5 62
Stearn	·31	9 9	3 24	·33	8·8	3·84	·33	7·4	4.42
Ediswan, Old ...	·405	8 5	4·81	·40	8	5·00	·43	8	5·41
Ediswan, New ...	·37	7·6	4·91	·37	7·2	5·11	39	7	5·71

* Mean of three lamps.

leaves off appreciably higher. The vagaries played by incandescent lamps are often very inscrutable as manufacturers of lamps are only too well aware. The Ediswan 10-C.P. lamps for instance, manufactured presumably by the same methods as the 16-C.P. and running from the start at a lower and far more favourable efficiency as regards deterioration of the lamps, should, one would have thought, have shown better results than the 16-C.P. lamps. The same consideration should apply to the Phaeton, and yet the discrepancy in this case is still more marked. On the other hand the opposite result occurs with the Brush Company, the Allgemeine and the Sunbeam 10 and 16-C.P. lamps. In consequence of signal discrepancies like these in the behaviour of lamps turned out by one and the same maker, consumers should be careful in judging of the quality of a certain make of lamp from the results obtained from a particular batch that may have been tried.

ALTERNATE CURRENT MOTORS.

By W. G. RHODES, M.Sc.,
City and Guilds of London Institute. Central Technical College.

(*Continued from page* 494.)

Let us consider fig. 18, which represents the stator of a tri-phase induction motor. The currents in the coils A, B, and C are respectively $i \sin pt$, $i \sin \left(pt + \frac{2\pi}{3}\right)$, and $i \sin \left(pt + \frac{4\pi}{3}\right)$, where i is the maximum value of the current in any one of the circuits. Let n be the number of turns of wire in each of the windings A, B, and C.

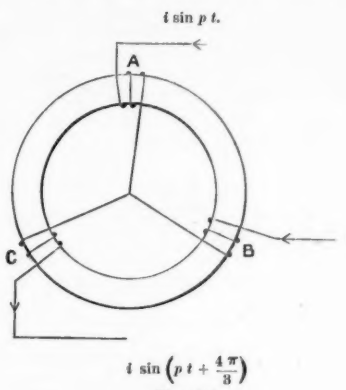


FIG. 18.

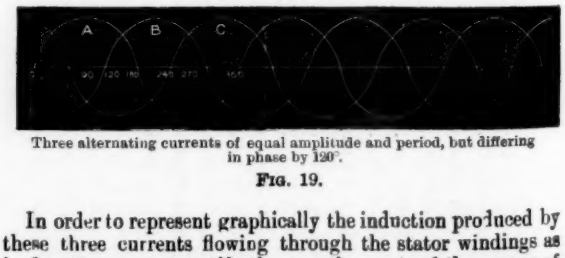
At time $t = 0$, the current in A is zero and increasing; that in B is $+ \frac{\sqrt{3}}{2} i$, and diminishing, while that in C is $- \frac{\sqrt{3}}{2} i$, and increasing (negatively). The nature of the winding is such that at the instant the currents in the coils B and C conspire to produce a south seeking pole at A, the induction being proportional to $\frac{\sqrt{3}}{2} n i$. At any subsequent instant given by $t = \tau$, where $p\tau$ is less than $\frac{\pi}{3}$, the currents in A and B act together in magnetising one-half of the stator, whilst C magnetises the other half; when $p\tau$ is greater than $\frac{\pi}{3}$, but less than $\frac{2\pi}{3}$, B and C act together, and so on. Thus it is seen that the currents in A, B, and C always help each other in producing a magnetic field. It should be noticed that this mutual assistance of the currents in the coils to produce a magnetic field is due to the way in which the stator is wound.

The sum of the currents in A, B, and C is

$$i \sin pt + i \sin \left(pt + \frac{2\pi}{3}\right) + i \sin \left(pt + \frac{4\pi}{3}\right),$$

which is zero for all values of t, so that the windings on the stator might have been such that, with the same three currents, the induction would always have been zero.

Three alternating currents of the same amplitude and period, but differing in phase by $\frac{2\pi}{3}$ are represented in fig. 19.



Three alternating currents of equal amplitude and period, but differing in phase by 120°.

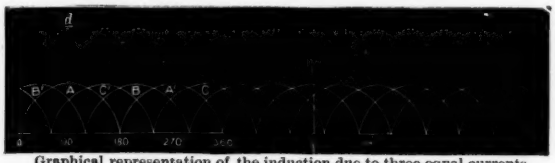
FIG. 19.

In order to represent graphically the induction produced by these three currents flowing through the stator windings as in fig. 18, we must rectify the negative parts of the curves of

fig. 19, and then add all the curves together. The result of adding these curves together is to produce the dotted curve in fig. 20, which represents the value of the induction at any instant.

As we remarked before, in our treatment of di-phase motors, our justification for rectifying the *current* curves to obtain an *induction* curve lies in the fact that the windings on the stator are such as to cause the three currents always to assist each other in producing a magnetic field, so that, whether any one of the three currents be positive or negative, it always assists in producing a positive induction in the stator.

In fig, 20, then, A, B, and C correspond to A, B, and C of fig. 19, while A′, B′, C′ correspond to the negative portions



Graphical representation of the induction due to three equal currents differing in phase by 120°.

FIG. 20.

of A, B, and C rectified. The curve d is obtained by adding A, A′, B, B′, C, C′ algebraically together, and represents the induction in the stator due to the simultaneous action of the currents A, B, and C.

From fig. 20 we see that the maximum value of the induction is proportional to

$$i + 2\,i \sin 30°,$$

that is, to $2\,i$,

and the minimum value of the induction is proportional to

$$2\,i \sin 60° \text{ or } i\sqrt{3}.$$

Thus the induction varies between limits which are proportional to 2 and 1·732, and the total variation is 15·6 per cent. of the minimum induction, or the variation from the mean value of the induction is about 7·2 per cent.

Comparing this result with that which we obtained for a di-phase induction motor, we see that increasing the number of currents round the stator diminishes the percentage variation of the induction from its mean value.

The steady running of an induction motor depends upon the constancy of the torque on the rotor, and consequently upon the constancy of the strength of the magnetic field in which the rotor revolves. We might, therefore, be led to suppose that the greater the number of currents, in different phases, exciting the stator, the steadier would be the action of the motor. Practical experience, however, tells us that a

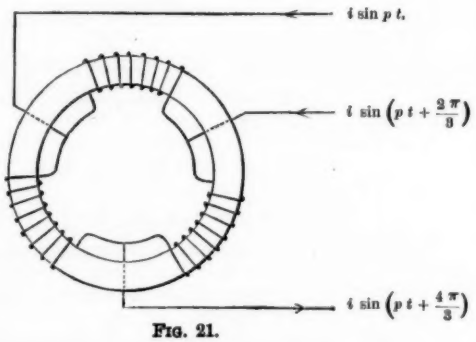


FIG. 21.

di-phase motor will usually work quite as steadily as a tri-phase motor. This is probably due to the influence of the rotor currents which will tend to diminish the variations of the induction.

We shall have to return to a further consideration of the currents in the stator windings and the potential differences at its terminals. We may mention, however, before passing on to consider the rotor, that there are two methods of winding the stator coils; one, called the "Star Winding," is represented in fig. 18; the other, called the "Mesh Winding," is shown in fig. 21. The respective advantages of the two methods of winding the stator will be discussed in a subsequent article.

In our last article we laid particular stress on the similarity which exists between an ordinary alternating current transformer and an induction motor.

We now proceed to show that both of these machines are but particular cases of a more general transformer.

The ELECTRICAL REVIEW for April 5th, 1895, contains an article by Mr. Rankin Kennedy entitled "The Early History of the Polyphase Motor," in which is given Mr. Steinmetz's theory of the induction motor. Mr. Steinmetz * has quite recently generalised his theory, bringing out most clearly the close relationship which exists between the induction motor and the ordinary stationary alternating current transformer. Both of the above papers, though very excellent in their way, treat the subject by mathematical methods which are not known to the majority of electricians. We propose to give here the same physical conceptions, but to change the method of analysis so as to render it intelligible to those who are unacquainted with the use of "imaginary" quantities, as Steinmetz calls them.

THEORY OF THE GENERAL ALTERNATING CURRENT TRANSFORMER.

The general alternating current transformer is defined to be any electro-magnetic apparatus which consists of a magnetic circuit interlinked with two electric circuits or sets of electric circuits: the one, the primary circuit, is excited by an impressed E.M.F., while in the other, the secondary circuit, an E.M.F. is induced. The circuits may be either stationary or movable, so that the frequency as well as the current and E.M.F. will be different in the primary and secondary circuits.

Perhaps a little explanation is necessary to show how it is that the frequencies in the two circuits are, in general, different.

Consider an ordinary alternating current dynamo: the frequency of the current depends upon the angular velocity of the armature; the greater the velocity of the armature relative to the magnetic field, the higher the frequency. The frequency of a current in a conductor depends, then, upon the relative angular velocity of the conductor and the magnetic field in which it rotates, or upon the rate at which lines of induction link and unlink the conductor. It is obvious, then, that in the general alternating current transformer the frequency of the secondary current depends upon the relative angular velocity of the primary and secondary circuits.

Let, then, N = primary frequency,

and $k\,\text{N}$ = secondary frequency.

so that k is the ratio of the secondary frequency to the primary frequency, or the "slip" as it is called.

We notice that if $k = 0$, the secondary frequency is zero, and the secondary circuit is rotating in synchronism with the induction due to the primary current; if $k = 1$, the two frequencies are the same, and the secondary circuit is stationary.

Let n_0 = number of primary turns in series per circuit.

n_1 = number of secondary turns in series per circuit.

$a = \frac{n_0}{n_1}$ = ratio of turns.

Y = primary admittance per circuit = $\sqrt{\rho^2 + \sigma^2}$.

[Where ρ = virtual conductance = ratio of hysteretic energy current to the impressed E.M.F., σ = susceptance = ratio of magnetising current to the impressed E.M.F.]

I_0 = internal primary impedance per circuit = $\sqrt{r_0^2 + s_0^2}$,

where r_0 = resistance of primary circuit.

s_0 = reactance of primary circuit.

Let s_1 and s respectively represent the reactances of the internal and external secondary circuits when stationary. When the slip is k the respective reactances become $k\,s_1$ and $k\,s$.

* "Theory of the General Alternating Current Transformer." By C. P. Steinmetz. *Trans. Am. Inst. El. Eng.* 12, pp. 351—365, 1895.

If I_1, r_1, and I, r, represent respectively the impedances and resistances of the internal and external secondary circuits, we have

$$I_1 = \sqrt{r_1^2 + k^2 s_1^2} \text{ and } I = \sqrt{r^2 + k^2 s^2}.$$

Let, also, E_0 = primary impressed E.M.F. per circuit.
E'_0 = E.M.F. consumed by primary counter E.M.F.
E_1 = secondary terminal E.M.F.
E'_1 = secondary induced E.M.F.
e = E.M.F. induced per turn by the mutual magnetic flux, at full frequency, N.
i_0 = primary current.
i'_0 = primary exciting current.
i_1 = secondary current.

The total impedance of the secondary circuit

$$= \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}$$

Again, we have

$$E'_1 = k n_1 e.$$

Therefore

$$i_1 = \frac{k n_1 e}{\sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \qquad (1)$$

The potential difference at the terminals of the secondary is given by

$$E_1 = E'_1 - i_1 I_1 = i_1 I$$

$$= \frac{k n_1 e \sqrt{r^2 + k^2 s^2}}{\sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \qquad (2)$$

The E.M.F. consumed by the primary counter E.M.F. is

$$E'_0 = - n_0 e,$$

therefore, the primary exciting current is

$$i'_0 = E'_0 Y,$$
$$= - n_0 e \sqrt{\rho^2 + \sigma^2}.$$

The primary exciting current will, in general, be variable, and, consequently, so also will the primary counter E.M.F.

Now the total primary current, i_0, is the sum of the exciting current, i'_0, and a current, i''_0, corresponding to the secondary current, i_1, so that

$$n_0 i''_0 = - n_1 i_1$$

or,

$$i''_0 = - \frac{i_1}{a},$$

$$= - \frac{k n_1 e}{a \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}}.$$

Therefore

$$i_0 = i'_0 i''_0$$

$$= - n_0 e \sqrt{\rho^2 + \sigma^2} - \frac{k n_1 e}{a \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}},$$

$$= - k n_0 e \left\{ \frac{\sqrt{\rho^2 + \sigma^2}}{k} + \frac{1}{a^2 \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \right\} \qquad (3)$$

The primary impressed E.M.F. is given by

$$E_0 = E_0' + i_0 I_0,$$

$$= - n_0 e - k n_0 e \sqrt{r_0^2 + s_0^2} \left\{ \frac{\sqrt{\rho^2 + \sigma^2}}{k} + \frac{1}{a^2 \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \right\}$$

$$= - n_0 e \left\{ 1 + \sqrt{r_0^2 + s_0^2} \sqrt{\rho^2 + \sigma^2} + \frac{k \sqrt{r_0^2 + s_0^2}}{a^2 \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \right\} \qquad (4)$$

Equations (1), (2), (3), (4) give the secondary current, the secondary terminal voltage, the primary current and the primary impressed E.M.F.

Dividing (3) by (1) we get for the ratio of the primary to the secondary current,

$$\frac{i_0}{i_1} = - \frac{1}{a} \left\{ 1 + \frac{a^2}{k} \sqrt{\rho^2 + \sigma^2} \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2} \right\} \qquad (5)$$

and dividing (4) by (2), the ratio of the primary impressed E.M.F. to the potential difference at the terminals of the secondary is

$$\frac{E_0}{E_1} = - \frac{a}{k} \cdot \frac{1}{\sqrt{r^2 + k^2 s^2}} \left\{ \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2} \left[1 + \sqrt{r_0^2 + s_0^2} \sqrt{\rho^2 + \sigma^2} \right] + \frac{k}{a^2} \sqrt{r_0^2 + s_0^2} \right\} \qquad (6)$$

Also the total apparent impedance of the primary is

$$I_0' = \frac{E_0}{i_0}$$

$$= \frac{\left\{ 1 + \sqrt{r_0^2 + s_0^2} \sqrt{\rho^2 + \sigma^2} + \frac{k \sqrt{r_0^2 + s_0^2}}{a^2 \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \right\}}{k \left\{ \frac{\sqrt{\rho^2 + \sigma^2}}{k} + \frac{1}{a^2 \sqrt{(r_1 + r)^2 + k^2 (s_1 + s)^2}} \right\}} \qquad (7)$$

It is to be noticed that $k s$, the external secondary reactance, supposes that the secondary circuit contains *inductive* reactance only. In a condenser, the reactance varies inversely as the frequency; so that if the secondary circuit contains a condenser, the reactance will be of the form

$$k s' + \frac{s''}{k}$$

We may write equations (1) to (7) as follows:—
Secondary current is

$$i_1 = \frac{k n_1 e}{I_2}$$

where I_2 = secondary impedance.
Potential difference at terminals of secondary

$$E_1 = \frac{k n_1 e I}{I_2}$$

Primary current

$$i_0 = - k n_0 e \left\{ \frac{Y}{k} + \frac{1}{a^2 I_2} \right\}$$

Potential difference applied at the terminals of the primary

$$E_0 = - n_0 e \left\{ 1 + I_0 Y + \frac{k I_0}{a^2 I_2} \right\}$$

Ratio of primary to secondary current

$$\frac{i_0}{i_1} = - \frac{1}{a} \left\{ 1 + \frac{a^2}{k} Y I_2 \right\}$$

Ratio of primary impressed E.M.F. to secondary terminal potential difference

$$\frac{E_0}{E_1} = - \frac{a}{k} \cdot \frac{1}{I} \left\{ I_2 + I_2 I_0 Y + \frac{k}{a^2} \cdot I_0 \right\}$$

Total apparent impedance of primary

$$I'_0 = \frac{1 + I_0 Y + \frac{k I_0}{a^2 I_2}}{k \left\{ \frac{Y}{k} + \frac{1}{a^2 I_2} \right\}}$$

$$= \frac{a^2 I_2 + a^2 I_0 I_2 Y + k I_0}{a^2 I_2 Y + k}.$$

(To be continued.)

THE CONTROL OF TRANSFORMER LOSSES ON CONVERTING SYSTEMS OF ELECTRICAL SUPPLY.

By JAMES WHITCHER, A.I.E.E.

(Continued from page 559.)

For separate circuit systems the arrangement at fig. 5 would suit. The alternator armature is in two equal sections, and the compound change-over switch enables them to be put in parallel or series as required.

In general, much of the foregoing description may apply equally to continuous as to alternating current systems. Modifications are necessary, due to the practical differences of the plant; but the principle remains much the same. Large and more elaborately equipped sub-stations are a necessity. The motor-dynamos are grouped on the mains as described; but their excitation demands further consideration. The large ones are best excited by shunts on their secondary side, and series windings on the primary side, to compound for the drop through both armatures. One of each pair of balancing motor-dynamo is treated likewise; the other must be designed for a rapidly reversible field, or reversible rotation. One means of reversing the field would

be to have a secondary shunt, as in the other, and a very powerful primary series, the over-compounding being balanced by a counter secondary series. The shunt will need protection, unless the change-over be made slowly. This reversible machine may also be a simple dynamo, coupled to the shaft of the other of the pair.

Batteries cannot be used on both sides of this system, and for this and other objections to reversing direct current supply mains, it would often be necessary to adopt some method of switch control instead.

. . . . . .

We may pass on now to the author's "changing phase" system, briefly described already as No. 7. As stated, it is identical with the preceding in the distribution arrangements outside the central station. These are generally as shown in fig. 1. The difference consists in charging the sides of the primary three-wire feeders, with alternating E.M.Fs.,

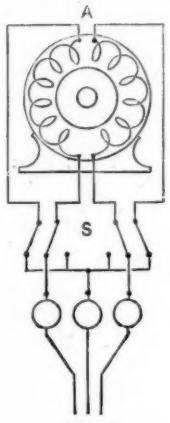


Fig. 5.

equal and similar, but differing in phase relative to each other; and this phase difference is adjustable, so that any E.M.F., and from zero to a maximum, may be obtained across the outer conductors of the mains, while that on each side remains constant. This results from the combination of the two latter E.M.Fs. The effect of the combination will be better understood if explained by graphical methods.

Thus, in the clockface diagram, fig. 6, let the projections on the vertical axis of the equal rotating radii, B and C, represent the E.M.Fs. on the two sides; then the angle, θ, between them, represents the phase difference between the E.M.Fs. By the well-known theorem, the line, B, C, is the resultant of B and C, and therefore it, or the rotating radius,

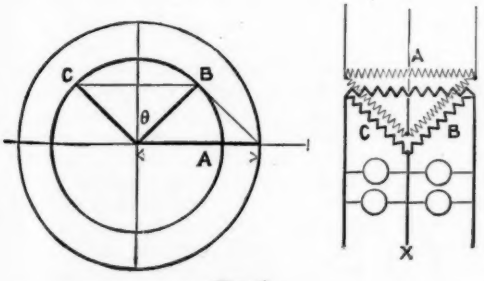


Fig. 6.

A, equal and parallel to it, represents the resultant E.M.F. across the outers, both in magnitude and phase. It is clear how A will vary in magnitude with different values of the phase angle, θ, from zero to twice B or C; and, further, that when A = 0, B and C are consonant in phase, or in parallel; and when A = 2 B, they are opposite, or in series. It is these two latter conditions that are utilised in the simple system preceding, the change-over being a step from one to the other. But the present system is designed to make use of the intermediate steps as well.

The phase and other relations will be exactly reproduced on the secondary network. Hence, considering the diagram of a "complete transforming unit" at X, fig. 6, it is readily apparent that, although the nominal E.M.F. of the large transformer, A, may fall far short of the sum of the nominal E.M.Fs. of B and C, yet the instantaneous E.M.F. of any single element is always equal to the sum of those of the remaining pair. Therefore, any one element will feed load in parallel with the other (series) pair; and A will work in parallel with the series, B, C, the load being shared in inverse proportion to the resistances.

The practical result is, that the induction in A, its activity, and iron loss, are capable of graduated control by means of a graduated adjustment of the phase difference or angle, θ, and therefore they can be kept proportional to the useful load, within limits, whereby the converting plant may be worked at a maximum efficiency for any value of the load.

The value of the phase difference required for various loads depends upon the transformer resistances, or, rather, impedances, as the self-induction due to magnetic leakage must be taken into account. Treated algebraically, the problem of finding it is extremely tedious; but it makes rather a neat and interesting study in graphics. Fig. 7 is a diagram of

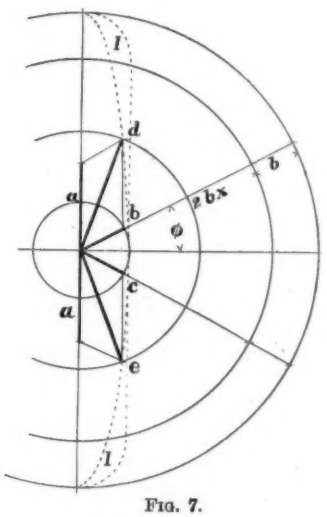


Fig. 7.

the currents on the secondary side of a transforming unit. Here the loads on the sides of the three-wire mains, taken equal for simplicity, are represented by the vertical projections of a certain pair of radii of the circle, d, e, the angle between them being roughly equal to the phase angle, θ. The one, d, is clearly the resultant of the currents, a and b, from transformers, A, B; and the other, e, that of those a and c in A and C. Note the current, a, stands in opposite relations to b to what it does to c, whence it must be defined by a diametrically opposite radius, when combined with c, to that when combined with b. It is required to find the smallest value of the phase angle θ, which satisfies this construction, without the currents, b, c, exceeding their safe maximum. Now, a is in phase with its E.M.F., which by fig. 6 is $(90° - \theta/2)$ in advance of that of b. Let radii of the circle, b, c, define the safe maximums of currents, b and c. It is now easy to see that the minimum phase angle occurs when the line joining d, e, is tangent to the circle, b, c, and the radii, b and c, coincide at the point of contact.

Thus we find that $\cos. \theta/2 = b/d$, is the relation that should obtain. It means that there should be 90° phase difference between the currents from the large transformer and those from the small, except, of course, near full load, when they should come into synchronism. The dotted line, l, l, is the locus of the ends of the load radii, d, e, for all values; set out to this line, the angle between them is practically the phase angle required between the two primary E.M.Fs., presuming the above relation can be ensured.

It can be approached closely enough by proportioning the "drops" through the three transformers in suitable manner. To determine this, set out as in fig. 8 a diagram of the E.M.Fs. corresponding to the currents of fig. 7. Take the radii, D and E, to denote effective pressures on the mains. Each of these is resultant of two sets of E.M.Fs.:—(1) The impressed E.M.F. of transformer A (fig. 6, X) + that of B or C + the drop in A + the drop in B or C; (2) The im-

pressed force of B or C + the drop of B or C. From which we arrive at the construction figured: the line, b^1, extended from D in given direction, representing the drop in B, when passing the current, b, of diagram 7; so that the line, B, completing the triangle, indicates the E.M.F. of B. Likewise, c^1 and C are the drop and E.M.F. of C, and a^1 and A, those of A. It can now be seen that the angle ϕ, which b and c makes with the median line bisecting θ, depends upon the ratio between the drops, a^1 and b^1 or c^1. For, if the

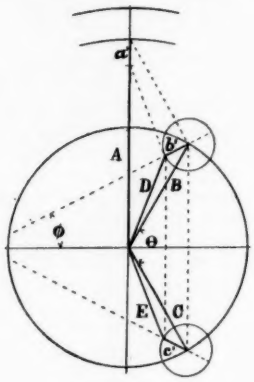


Fig. 8.

"drop compensation" be similar in all the elements, sin. $\phi = a^1/2\ b^1$: or, as element B has x times the resistance of A, sin. $\phi = a/2\ x\ b$. And it results that

$$d = \frac{(2x+1)\ b}{\sqrt{1 - 4x(x+1)\cos.(\theta + z)}}.$$

By which it appears that the load locus for this case is an ellipse, with $(2x + l)\ b$ and b as axes, as dotted in on fig. 7. The angle, z, being that between B and D, fig. 8, is negligible on a diagram to scale.

If A be given a higher proportion of drop, and compensation to correspond, than those of B and C, then $2\ b\ x$ sin. $\phi = a -$ sin. $\theta/2.\ k/r$: where k is the extra compensation and r the resistance of A. The resulting locus is a line between the ellipse and l, l, fig. 7.

(To be continued.)

REVIEWS.

The Practical Engineer Pocket-Book and Diary. Edited by W. H. Fowler, Wh. Sc. Technical Publishing Company, Limited, 6, Victoria Station Approach, Manchester.

As this book has now reached its seventh annual issue, it seems firmly established as a hardy annual, and, indeed, it deserves to be, for there is certainly a very large amount of useful tables, formulæ, and general information given at a low price. It is, however, somewhat of an exaggeration to speak in the preface of the book containing upwards of 400 pages, for although this is literally true, no mention is made of the fact that about 130 of this 400 consist of index, advertisements, and blank diary pages, which materially reduces the number representing what may be called the "useful" matter. An addition of 50 pages of notes, &c., dealing with electrical engineering, has been made. These latter pages have been compiled by Mr. S. T. Harrison, of University College, Cardiff, and the information has been judiciously selected.

Elements of the Mathematical Theory of Electricity and Magnetism. By J. J. Thomson, M.A., F.R.S., Hon. Sc.D., Dublin, Cavendish Professor of Experimental Physics in the University of Cambridge. University Press, Cambridge.

The author points out that it is not at all necessary to make use of advanced analysis to establish the existence of some of the most important electro-magnetic phenomena, and that there are always some cases which do not require an elaborate analysis. This is an admission which it would be as well if others besides Prof. Thomson would act upon. There is always a tendency where an elaborate analysis is vitally necessary to tar everything with the same brush for the sake of uniformity, and it is to be regretted that this policy is carried out to the extent it generally is. Doubtless it is partly because those who treat of high analysis are very often positively incapable of descending to lower levels, for the reason that what appears easy to themselves they conclude is also easy to everyone else. In the book in question, with a few exceptions, no more advanced mathematical knowledge is required than an acquaintance with the elementary principles of the differential calculus. In explaining how the E.M.F. of a Daniell's cell may be calculated from the chemical energy, it is shown that the theoretical value would be $1{\cdot}114 \times 10^8$, but that the actual value is $1{\cdot}028 \times 10^8$. We do not know how this latter value was obtained, but it is distinctly below the truth; a Daniell cell has an actual force of very nearly 1·1 volts, which is close to the theoretical value. The simple method of treatment of many of the problems is not entirely a satisfactory one, as in many cases it will be found to consist of statements of facts which are not at all obvious except, doubtless, to the author. With reference to the Wheatstone bridge, it is pointed out that by its means a definite and very minute difference of potential can be obtained, thus with the four arms of the bridge in the ratio of 101 : 99 : 100 : 100, and with G = 1, then the potential between the ends of G will be but one four-millionth of the E.M.F. at the battery terminals; this is a point which we do not think has been taken notice of before. The all interesting subject of electro-magnetic induction is very fully considered, but here statements of fact are made to do duty for simple explanations to far too large an extent, with the result that the student becomes tantalised and not satisfied. Much, therefore, as there is in the book of value, there is a good deal left unsaid, which it is very necessary to know before its use can be appreciated.

Engineering Contracts and Specifications. By J. B. Johnson, M.Am.Soc.C.E. *Engineering News* Publishing Company, New York. 1895.

The author is already favourably known by his books on bridges and surveying, and the present volume is worthy of him also. Written primarily for the use of American engineering students, it has been also made to suit the engineer in practice and the contractor, and though it is for Americans that Mr. Johnson writes, the information should, we fancy, be welcome to English engineers as well. There may be differences in the laws of the two countries, but substantially American law is modelled on English, and where America provides no statute, English law and precedent always has to serve. While holding to the opinion that the man who is his own lawyer has a fool for a client, it has been endeavoured to present a brief exposition of contract law for general purposes only, and, so far as we can judge, this has been well done. In the more immediately technical portion of the volume is found information as to advertising a contract, proposal forms, the general clauses of specifications and examples of actual specifications, such as Bouscarens on bridgework, specifications for cement, masonry, earthwork, bricks, sewer pipe, iron and steel, a canal lock, and very many other actual works which have been carried out. One peculiar specification is that of the City of St. Louis for high duty pumping engines, for the City is bound to accept the lowest tender or none, and therefore special care is needed in drawing the specification. In the case of these engines, the contractor had to supply his own plans, and was provided simply with about seven figures as data, and a duty figure of 125,000,000 foot-pounds per 1,000 lbs. of steam used. This, and other specifications in the book, are on the whole sound and good. There is an absence of the impossible clauses which so frequently disfigure specifications, and for which certain quarters among engineers' offices or streets, have a notoriety. Recently we had a specification before us of an engineer who is at the forefront of his special line. Yet his specification called for a class of work long since out of date, and inferior to the present style of work altogether; and again, a few months ago, we were shown a specification by this same man, which called for certain works to be done in just the reverse order from what was right and honest. Indeed, the one standard paper on which many engineering

specifications seem to be drafted may be said, when held to the light, to bear this watermark [5%].

Small towns, villages of paupers, and insignificant hamlets, are called upon to pay their thousands for public work which would be far better executed for a matter of hundreds. Certain work is now in progress for the town of X, the work has been carried out and results obtained, but a board composed of labourers, masons, carpenters and parsons, says, No, we will not accept the work until it is in conformity with the letter of the specification, and the contractors are now being put to big expense in order to spoil the work. It is to such ignorance as this that there is due so much of the roguery with which contractors are credited, but it is a common saying among contractors, that when they will be honest they are not allowed to be so, and there is a good deal of truth in this. It is a pity more standard specifications cannot be from time to time published and brought up to date which, avoiding timidity on one hand and rashness on the other, shall be fit instruments to hold the balance evenly between a contractor and his employer. Is an engineer justified in awarding a contract to a firm who have bid less than the work can possibly be carried out for? We incline to a negative unless such contractor can show very excellent reasons for so doing, such as may sometimes be advanced. We doubt altogether the wisdom of allowing a tenderer to tender at a loss for advertisement's sake. Such a one must always have an *arriere pensee*, and be tempted to try to squeeze a profit after all.

Institution of Civil Engineers.—On Tuesday next, 19th inst., Mr. J. H. Greathead, M.I.C.E., will present a paper on "The City and South London Railway: Sub-Aqueous Tunnelling by Shield and Compressed Air."

THE USE OF THE CONTROLLER FOR ELECTRIC RAILWAYS.*

In our last issue we described the power station and much of the detail of the lines of the Fair Haven and Westville Railroad plant. We now give details of the electric wiring of a trolley car and other items of interest connected with the railroad.

A passenger on an electrically propelled car, unless he happens to be an electrician, has very little idea of the maze of wiring and the intricacy of the switches necessary for the complete control of the current used on a car. The current, which is taken from the trolley wire above by the mere touch of the trolley wheel, and is delivered to the track, which, in connection with the ground and return wire, forms a return circuit, must be able to develop as much as 50 horse-power for starting the car, for grades, for overcoming obstructions,

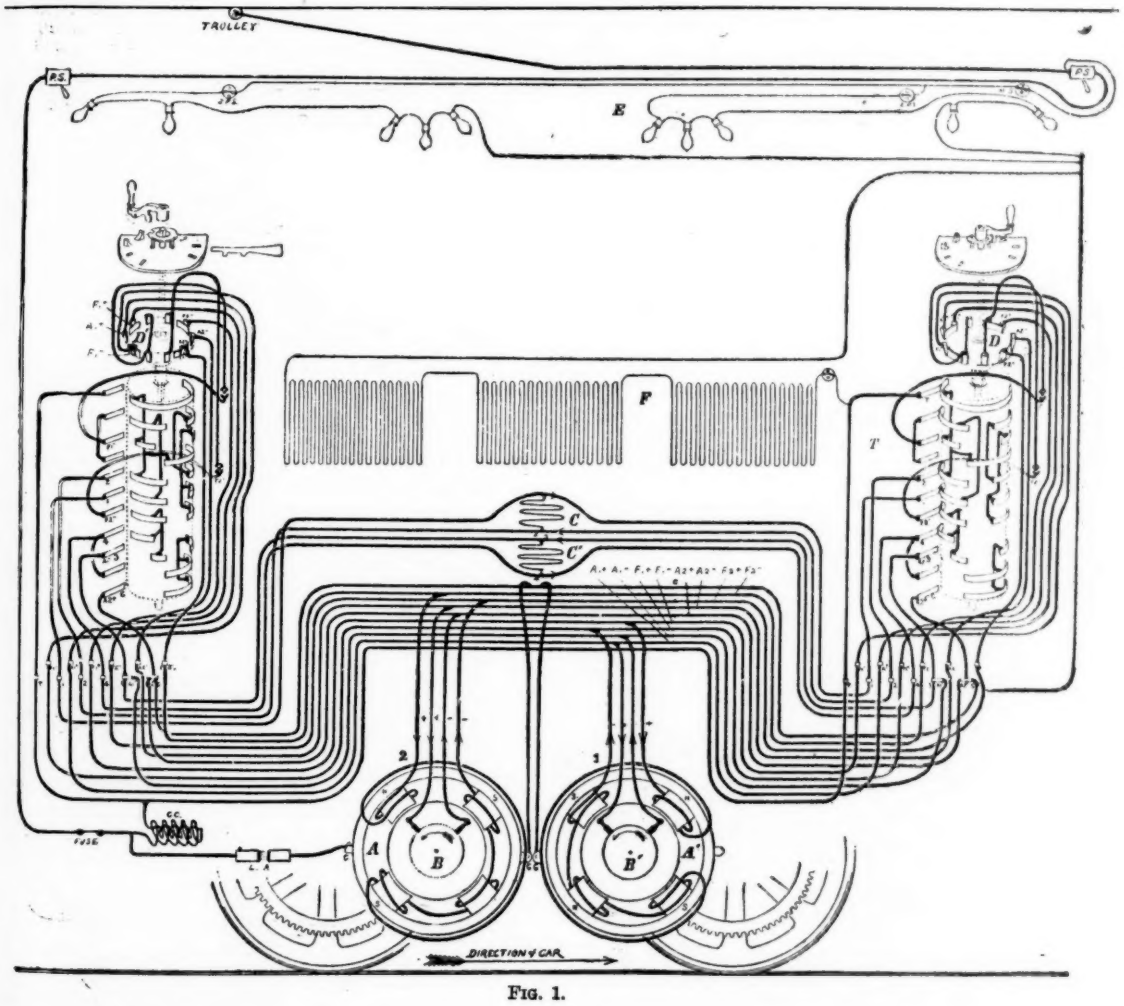


Fig. 1.

and for towing a trailer or a disabled motor car, and it must also be controllable to any extent so as to produce any desired power from the fraction of a horse-power up to the full capacity of the motor or motors. In addition to this the current is utilised for lighting and heating the car.

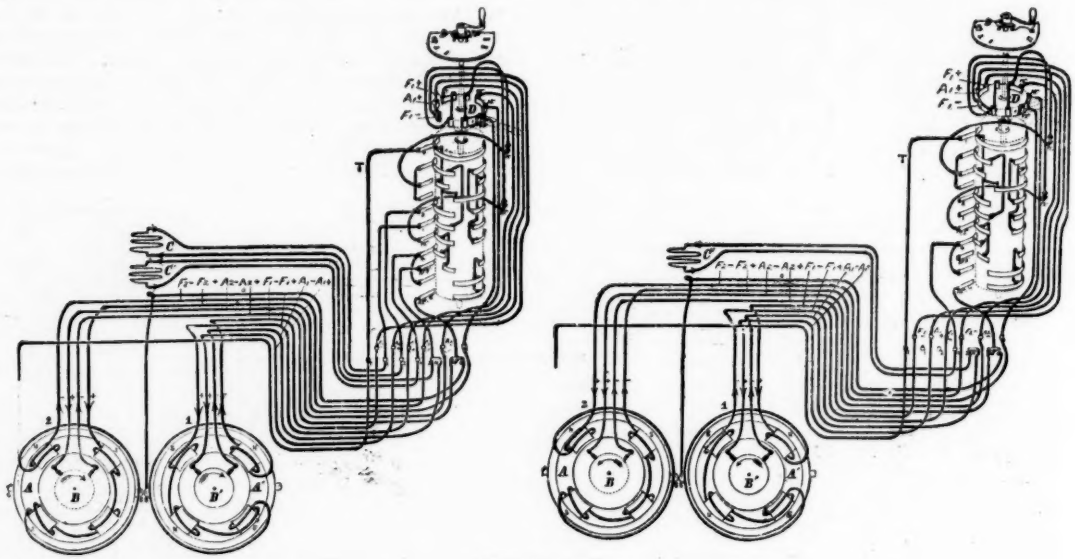
To cause the car to stop or start, to go forward or backward, slow or fast, and to permit of operating it from either end, there is placed on each platform a box known as the "controller," having to hand levers at the top, one for reversing the motor, the other for varying its speed and stopping. The controller contains insulated contact springs forming the terminals of the various wires, and also a cylinder carrying a number of metallic segments for forming the various connections of the wires by contact with the different springs.

* *Scientific American.*

The connections, as shown in the diagram, fig. 1 (which represents the wiring of a car), are arranged for starting the car, *i.e.*, with all the windings of the field-magnets in series with the two armatures and the two resistances, C, C′. These connections can be traced by starting at the power switch, P, S. Between the power switch and the motors are located the fuse and the choke coil, *c c*, which latter is designed to impede a lightning discharge so as to cause the lightning to pass to the ground through the lightning arrester, L A, ground connection, G, motor box, car wheels and truck, rather than through the motors.

The current passes to the wire, T, which is open at the rear controller, but which in the front controller touches the upper segment which communicates through wire 2 with resistance, C, thence through wire 1 and the segment with one of the contacts in the reversing switch, D. The current flows thence to the field magnet of the motor, B′, through the wire, F′−, and returns to the reversing switch through the wire, F^1+, thence through the wire, A′+, to the armature of the motor, B′, through the wire, A′+, to the resistance, C′, thence back to the spring, 4, of the controller, thence to the spring, F^2-, through the reversing switch wire, F^2-, to the field magnet of the motor, B, returning through the wire, F^2+, to the reversing switch, thence to the armature of the motor, B, by the wire, A^2-, returning by the wire, A^2+, to the ground wire, G, which communicates with the ground through the motor box, car truck, car wheels and rails.

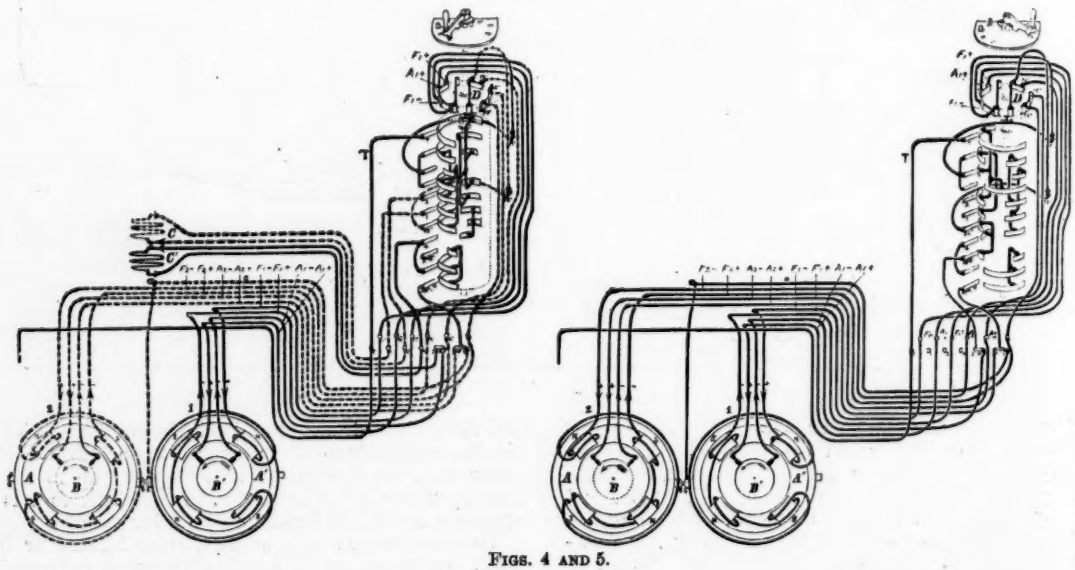
Fig. 2 shows the arrangement of the controller and reversing switch when the motors are reversed. The current enters the trolley connection, T, as before, passing to spring, 2, thence to the resistance, C, spring, 1, to the wire, F′−, thence to the reversing switch, D, and wire, F^2+, to the field magnet of the motor, A′; thence back to the switch, D, thence by the wire, A′+, to the armature, B′, of the motor, A′, thence to the resistance, C′, to spring, 4, through the segment of the controller to spring, F^2-, thence by the wire, F^2-, to the reversing switch, D, thence by the wire, F^2+, to the field magnet of motor, A, thence to the switch, D, and back to the armature, B, of the motor, A, thence to the ground connection, C.



FIGS. 2 AND 3.

It will thus be seen that while the current remains the same in the armatures of the motors, it is reversed in the field magnets; this causes the armatures of the motors to revolve in the opposite direction.

When the controller lever is at the first notch the current is fully on, with both the field magnets, armatures and resistances in series, as shown in fig. 1. When it is at the second notch the resistance, C, is cut out, as shown in fig. 3. With the controller lever at the third notch both resistances,



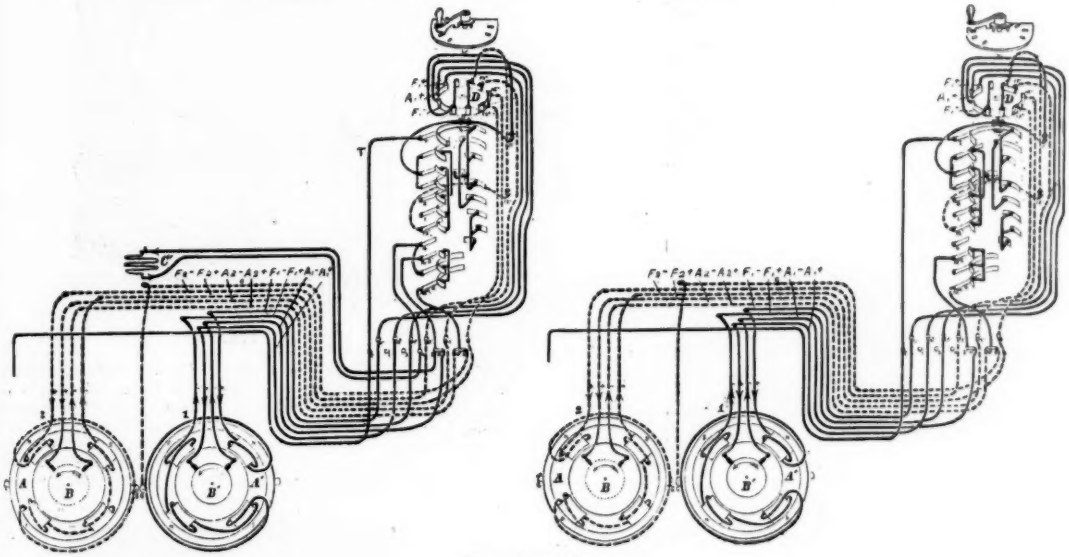
FIGS. 4 AND 5.

c c', are cut out as in fig. 4. At the fourth notch the motors are in parallel with each other and in series with the resistance (fig. 5).

When the controller is arranged as shown in fig. 6, the two motors are in parallel and in series with half the resistance. When the controller is arranged as in fig. 7, both motors are in parallel, the resistances being cut out. Circuits shown in dotted lines are in parallel with like circuits shown in full lines.

These various changes in the circuit give all the gradations of power required for starting and for running at different speeds.

The heating apparatus, F, which consists of a series of wire coils arranged under the seats behind gratings, is in parallel with the electric lighting apparatus and the motors.



FIGS. 6 AND 7.

Enough current is taken from the supply wire to maintain a comfortable temperature in the car. There are two lamp circuits on the car, each including five 100-volt lamps, the lamps of each set being in series.

At suitable intervals on the various branches of the road there are telephone boxes, by means of which the engineer or electrician at the power station can be notified of anything occurring on the lines, and by which the dispatcher is informed whenever an emergency arises calling for more than the usual number of cars.

Much of the perfection of this trolley system is due to the efforts of Mr. Francis G. Daniell, electrical engineer for the company, who has kindly furnished us with the data here presented.

THE RATING AND BEHAVIOUR OF FUSE WIRES.*

By W. M. STINE, H. E. GAYTES, AND C. E. FREEMAN.

(*Continued from page 571.*)

The results plotted in fig. 2 are significant. The upper curve was obtained from three-ampère fuses in the covered block. The curve is here more sharply marked than in the case of the same wire blown in an open block. This was found to be true for all sizes of wires tested in this manner, and indicates that a fuse is more sensitive in a covered than in an open block. In this case the shorter distance between the terminals raised the fusing point, and increased its inertia for higher currents.

It was considered desirable to obtain data which should exhibit the action of the fuse with the cooling effect of the terminals eliminated. To accomplish this, the fuses were blown in lengths of 8 inches, with asbestos supports placed each inch of length, the black in all cases being horizontal. The supports practically prevented the breaking of the fuse from hydrostatic pressure. The results with A and B wires, and the German silver (18 per cent.), as well, are shown in figs. 3—6. It was supposed though such curves are hyperbolic, that for abnormally high currents they would exhibit somewhat constant inertia times, due to the oxide coating and other mechanical causes. The results clearly confirmed this, the inertia time constant in some cases amounting to two seconds.

The blowing of the fuse is not immediately an electrical act. The current fuses the metal, the cross-section is reduced at some point due to gravity, unequal expansion, or "sweating"; the heat in consequence intensifies at this point, and a globule falls, breaking the circuit and establishing an arc, which soon burns out a length of the fuse. This accounts for the sluggish action of such thermal cut-outs. An ideal fuse would be one that would act at approximately a constant time interval for all currents in excess of its normal. It would, in this respect, closely resemble the action of an electro-magnetic cut-out. Its curve would be a straight line extending from its normal point, and slightly approaching the vertical axis for all abnormal currents, being thus identical with the curve of the electro-magnetic cut-outs. In practice the curves of all thermal cut-outs must be more or less modified hyperbolas. The ideal curve could only be attained were it possible to eliminate conduction and radiation losses. This is evidently the line to follow in designing a sensitive fusing block.

The curves in figs. 3 and 4 clearly exhibit the relative sensitiveness of small and large fuse wires, the smaller diameters approach more nearly the ideal condition. This is of great practical interest in guarding against excessive currents of short duration, such as motors are subject to when operated from street railway and power circuits. In such cases a multiple fuse of four pieces of five-ampère wire

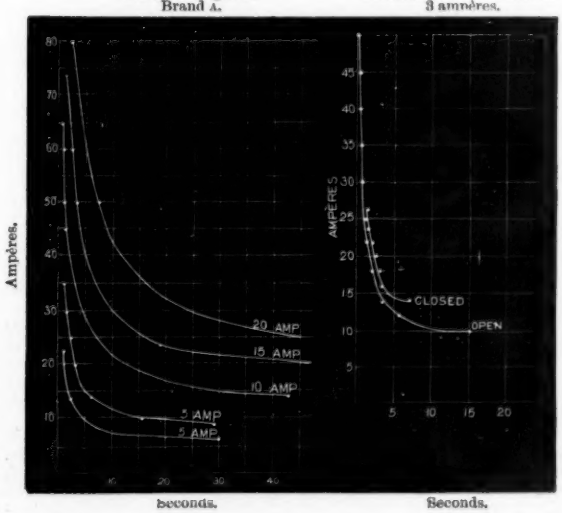


FIG. 3. FIG. 2.

would prove from two to three times as sensitive as one piece of 20-ampère size. Such multiple fuses have been found by the writer to effectually prevent the belt slipping off the pulley of small dynamos under short circuits. The sluggishness of large fuse wires may be due to the cooling of the outer layers which, with the oxide coating, prevent the fuse from breaking. It is evident that this effect would be less in small wires. For this reason a thin ribbon should prove more sensitive than a round wire.

* Presented at the meeting of the American Institute of Electrical Engineers, New York and Chicago, October 23rd, 1895. Subject to revision.

that the average candle-power of the "Robertson" 8 candle-power lamps is nearer the nominal value than that of the other three makes, and with the 16 candle-power "Robertson" lamps, these are only slightly excelled in this respect by one other make. Your above remark, therefore, about the "Robertson" "losing ground in virtue of its lower average candle-power" is not borne out by these figures.

TABLE I.

(From curves in ELECTRICAL REVIEW of November 1st, p. 536.)

100-*volt* 8-*C.P. Lamps* (*averages of* 6).

Name of lamp.	Price paid per lamp.	Tested at commencement.			Tested after 350 hours.			Tested after 600 hours.			Number broken, and when.
		Amps.	Candle-power.	Watts per C.P.	Amps.	Candle-power.	Watts per C.P.	Amps.	Candle-power.	Watts per C.P.	
	s. d.										
Robertson ..	1 3½	·35	8½	4·09	·35	8	4·37	·34	7½	4·53	One at 341 hours
Sunbeam ..	1 3	·38	8½	4·58	·41		5·12	·40	7½	5·41	....
Edison-Swan (Old)	1 9	·41	8½	4·82	·40	8	5·0	·43	8	5·77	....
Edison-Swan (New)	1 9	·37	7½	4·93	·37	7½	5·1	·39	7	5·57	One at 295 hours.

100-*volt* 16-*C.P. Lamps* (*averages of* 6).

	s. d.										
Robertson ..	1 0	·56	15	3·73	·57	15	3·8	·57	14½	4·0	....
Sunbeam ..	..	·61	14	4·35	·65	11½	5·65	·64	10⅓	6·21	....
Edison-Swan (Old)	..	·60	16	3·75	·61	15½	4·0	·64	14½	4·49	....
Edison-Swan (New)	..	·56	15	3·73	·57	14½	3·92	·59	14	4·21	One at 263 hours.

TABLE II.—COST OF MAINTENANCE, &c.

Based on Table I.

100-*volt* 8-*C.P. Averages during* 600 *hours.*

Name of lamp.	Average C.P.	Average watts per C. P.	Average watts per hour to give the nominal C.P.	Cost in shillings (1) per 600 hours, (2) per lamp, giving the nominal C.P.		No. of lamps required during 600 hours, as per Table I.	Total cost to maintain six lamps for 600 hours (renewals and current). Lamps at 1s. each.		Total cost to maintain six lamps for 600 hours (renewals and current). Lamps at cost paid on Table I.	
				6d. per B.T.U.	8d. per B.T.U.		6d. per B.T.U.	8d. per B.T.U.	6d. per B.T.U.	8d. per B.T.U.
Robertson ..	8·00	4·33	34·65	10·4	13·85	7·	17/4	20/10	19/3	22/9
Sunbeam ..	8·00	5·04	40·32	12·09	16·12	6·	18/1	22/1	19/7	23/7
Edison-Swan (Old)	8·30	5·20	41·6	12·48	16·64	6·	18/6	22/7	23/	27/1
Edison-Swan (New)	7·25	5·20	41·6	12·48	16·64	7·	19/6	23/7	24/9	28/10

100-*volt* 16-*C.P. Averages during* 600 *hours.*

Robertson ..	14·83	3·84	61·5	18·45	24·	6·	24/5	30/7	26/0½	32/2½
Sunbeam ..	11·90	5·40	86·5	25·95	34·	6·	31/11½	40/7	33/5½	42/1
Edison-Swan (Old)	15·19	4·08	65·4	19·62	26·16	7·	26/7½	33/2	31/10	38/5
Edison-Swan (New)	14·41	3·95	63·3	18·99	25·32	6·	25/-	31/4	29/6	35/10

In any case, however, the close agreement between actual and nominal candle-power is of no practical value, as a customer may choose that particular nominal candle-power which best suits his requirements, and this is not, therefore, a radical defect, as its amelioration lies in the customer's hands, whereas the smallness of the average watts per candle-power used during life is a radical virtue, and in this respect the "Robertson" lamps far exceed those of the other English makes, as pointed out by yourselves, and as shown by my Table II., which is based on the curves given in the ELECTRICAL REVIEW. This table shows the cost of maintenance of the various makes of lamps for a period of 600 hours, original cost of lamps, renewals and cost of current being taken into account. The greatest saving is in all cases obtained with the "Robertson" lamps of both 8 and 16 candle-power.

C. J. Robertson.

Incandescent Lamps.

Noticing an advertisement appearing in the ELECTRICAL REVIEW, stating that Messrs. Gabriel & Angenault's lamps excel all others, and that one is referred to in the test in *Industries and Iron*, of October 4th, 1895, I would be glad to know how this can be actually made out. From the figures given therein it appears to be quite the contrary, for at least, by evidence, all the English made lamps are its superior.

The annexed figures, taken from the tests published in the *Industries and Iron* issue of October 4th, compare the G. and A. lamps with one of the English made lamps, viz., the "Robertson," and in all respects whatsoever the "Robertson" seems to excel it by far in every point in which the excellency of a lamp is determined by a time and power test:—

	Average per cent. loss of C.P. in 600 hours.	Average per cent. increase in watts per C.P. in 600 hours.	Broken—and when.
100 volts, 8 C.P.			
Robertson	11½	11	1 at 295 hours
Gabriel and Angenault	25	13⅔	...
100 volts, 16 C.P.			
Robertson	3½	7	...
Gabriel and Angenault	19	12½	1 at 245 hours

Fredk. Walker.

73, St. Stephen's Road, Upton Park.

Sullivan's Universal Galvanometer.

As I am frequently asked how my Universal Galvanometer (described in the ELECTRICAL REVIEW of March 22nd last) behaves when used on board ship in a heavy sea, the following report dealing with that, as well as other points in the instrument, may possibly be of general interest. You would oblige me by kindly publishing the same:—

The Indiarubber, Gutta Percha
and Telegraph Works Company, Limited.

s.s. *Dacia*,
Off Cadiz,
October 27th, 1895.

Dear Mr. Sullivan,—I am pleased to be able to send you a very satisfactory report on your marine galvanometer. All the way out we have had a very heavy sea, so I have been able to give it a pretty severe trial. In every way I find that it is very superior to the old ironclad Thomson marine galvanometer. Not only is the narrow coil just three times as sensitive as our Thomson wound with 30,000 units, but owing largely to the inertia of the coil your instrument has been remarkably steady, while the Thomson suspension has been vibrating, under the vibration due to the propeller, to an extent which makes it very trying, and indeed almost impossible, to read with any great degree of accuracy in a heavy sea. There is no creeping, and the spot seems to return to zero. This coil is, however, very sensitive, and as I have not taken quite the same pains in making the balance absolutely perfect as yet, there is still a movement of about 5 to 10 divs. on either side of zero, when the ship is rolling very heavily, though for only moderate rolling there is little or no movement.

I have been very successful in balancing the wider coil, and find both of them more easy to balance than the Thomson suspension, as the latter is affected by the magnetic dip when held in different positions which has not to be taken into account when balancing your coil. It is a treat to watch the two suspensions at the same time, and to see how perfectly your instrument keeps its zero. Even when perfectly balanced, the Thomson suspension is displaced considerably from the scale zero, and is affected by the slightest vibration. When the ship changes its course, moreover, the zero changes, and has constantly to be checked. This weak point alone gives a great deal of trouble, more especially when testing the insulation of short lengths of cable, which I am glad to find your instrument is free from. Owing to the ship rolling very heavily, and carelessness in leaving the wide coil suspension insufficiently guarded on the table, while experimenting with the narrow coil, the wide coil suspending wires were both broken by sliding down the table against a key, so I very soon had occasion to try my 'prentice hand in re-suspending it. This was easily effected with the result I have already mentioned. I can quite believe that the wide coil is more suited for excessive vibration, but though the *Dacia* is moderately affected in that way by the propeller, both your wide and narrow coils are exceedingly steady. The sensitiveness of your narrow and wide coils, as I am now using them, is represented by 360 and 205 divisions respectively, compared with 130 divisions obtained under the same conditions with the Thomson. . . . . .

I told you that I had not quite balanced your narrow coil suspension, but I have not the least doubt but that it will be perfectly

immovable like the wider coil, when I can find time to touch up the balancing again. . . . . .

We are now entering Cadiz Harbour, and I am likely to be busy, so I must reserve a more careful and detailed report until I return to England, which, if the weather is suitable for our cable repairs, will be in about five weeks from present date, only I know you will be pleased to have another favourable report on your galvanometer.

Notwithstanding a sort of parental fondness which one has hitherto had for an only child, I am not sorry that our first has had his nose put out of joint at last, for my affection has often been sorely tried by the trouble the young rascal has given me. I have often marvelled at the patience an electrician has to exercise on board ship when following the erratic movements of his Thomson galvanometer, in order to obtain a correct insulation test, and I am sure many a one will cordially join with me in congratulating you on having turned out such a practical and satisfactory instrument.

I am, yours faithfully,
(Signed) John Rymer-Jones.

P.S.—If it will be any advantage to make use of this letter you are perfectly at liberty to do so.

I may add that the above corroborates a previous report received from another independent quarter.

H. W. Sullivan.

29, Ladbroke Square, W.
November 12*th*, 1895.

An Explanation.

Notices have appeared in your paper and elsewhere of a company styled the "British Electrical Manufacturing and Engineering Company, Limited," in the prospectus of which our name appears very prominently.

As this prospectus has been framed and issued to the public without our knowledge or consent, we shall be obliged if you will allow us space to explain the circumstances, as far as we know them, and to correct an inaccuracy which is important to us, and may be misleading to the public.

Finding that for our own work exclusively we could not advantageously run our brass-finishing works, and as it is not part of the business of electrical engineers to conduct works of this kind for the *sale* of brasswork, we determined to dispose of the machinery and stock in this department; accordingly we had agreed to sell them to the gentleman who appears as the vendor to the "British Electrical Manufacturing and Engineering Company, Limited."

We were expressly assured that no prospectus of any kind would be publicly issued, and as we feel that in the one which has come out contrary to this assurance, much has been made of a concern which, so far as our share in it goes, is of very slender proportions, and our name is used, appearing so that the public would naturally think we had authorised what is said, we wish to disclaim all responsibility for the announcement.

It is not true that we have undertaken to give the new company all our work. The fact is, that we have engaged to give them our orders for similar goods to those which we have heretofore ourselves made at our works, provided that they can do them as well, as to workmanship, price, and conditions, as we can get them elsewhere.

There is beyond these orders no goodwill in the department, and the expression that the company has acquired the goodwill of our manufacturing department is very misleading.

Laing, Wharton & Down.

[The only reference made in our columns to this company was the ordinary registration notice which appeared in our issue of October 25th, and our correspondents were not mentioned in connection therewith.—Eds. Elec. Rev.]

Block Signalling.

While thanking you for noticing my invention in your issue of November 8th, I would like to point out that your reviewer has not quite correctly stated the principle of my method. He says:—"In order to ascertain if a train were out of section . . . the signalman would have to pull off his signal in order to see if the bell were rung or not." Now, I should say that when the signalman places his signal to "line clear," which he *must do* in order to allow a train to pass, then if there be a train, or any portion of a train, ahead, the bell in the signal cabin would ring, and would keep on ringing till he placed his signal to danger; in other words, he would be warned of his error in plenty of time.

Again, as to the track circuit to which he takes exception, I would merely point out that it is now used by over 20 railway companies in America, and is found to work exceedingly well. Then, may I ask, Why should it not work as well here?

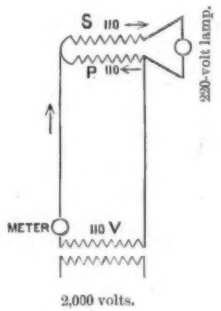
I shall conclude by quoting your own words on "Block Signalling," which appeared on October 4th, at p. 405:—"It is imperative for reliable working that the electric signals should be interwoven with the mechanical signals." Now, this is what my method proposes to do in a very simple manner.

Geo. C. Purvis.

Edinburgh, *November* 9*th*, 1895.

Raising the Voltage of Transformers.

Now that 200—220 volt lamps are coming into use, it may be well to recall a property of transformers that does not appear to be widely known, *i.e.*, that the secondary voltage can be added to or subtracted from the primary voltage. For instance, if the primary and secondary are wound with an equal number of turns and the primary connected to 110 volt mains, the 110 volts given by the secondary can be put in series with the primary 110 to produce 220. Or if the secondary is sub-divided, any part of it may be added to or subtracted from the primary voltage. It should be noted that it is the current at the primary terminals, *i.e.*, the street



current and not the current through the primary winding that is added to the secondary. The reason that this is possible is owing to the impedance of the primary winding throwing the current through it out of phase with the street current and the current through the secondary being in opposite phase to the primary the former is in phase with the street. If a 220 volt 100-C.P. lamp be burned from the transformer in question it need only be large enough for a 50-C.P. lamp. The current registered by the consumer's meter will be double the current that goes through the lamp.

The diagram is self-explanatory.

Leslie Miller.

November 11*th*, 1895.

Horseless Carriages.

Your "Note" upon the decision in the case of the petroleum carriage is not strictly correct. As the law now stands, after the decision in the Court of Queen's Bench in 1881, anyone, if prosecuted, *must necessarily* be fined in a magistrate's court, but on appeal, especially with a new defence, the complexion of affairs might be completely altered.

Mr. Knight, who was fined, had no intention of appealing, consequently the present state of things remains unaltered.

I will not enter upon a legal argument in your columns, since it would not be the proper place to do so, but this much has been written in the interests of electrical manufactures, since self-propelled electric carriages may become an important industry.

I am ready to try a test case myself, but I wait until the possibility of special legislation in the coming session has been determined. Before long this will be known from the steps which are being taken at the present moment.

David Salomons.

November 11*th*, 1895.

Overhead Wires.

Have the town corporation power to stop the erection of overhead low pressure cables for electric light belonging to private individuals, or can they only insist on regulations as to height, mode of erection, safety, &c. ?

Overhead.

Cork, *November 12th*, 1895.

[If overhead wires cross the streets the corporation have power to stop their erection. If permission is given to erect wires, however, they must be put up in accordance with the regulations of the Board of Trade.—Eds. Elec. Rev.]

J. C. Howell, Limited.

The paragraph appearing in your edition of the 8th inst. has been brought to my notice.

I beg to state that the liquidation has been brought about by the wish of the shareholders generally, for the purpose of disposing of the business and assets of the company.

Under the liquidation the shareholders have consented to my disposing of the same to Mr. J. C. Howell, as from the 1st inst., and negotiations are in progress for this purpose.

The liabilities of the old company will be discharged, not by me, but by the purchaser.

Sydney F. Isitt, *Liquidator*, per A.C.R.

November 13th, 1895.

Decay and Preservation of Telegraph Poles.

Referring to Mr. Langdon's paper, read before the Society of Telegraph Engineers, and to the discussion of May 13th, 1874, as shown on page 217 of Vol. ii. of the Electrical Review, it will, perhaps, be interesting to some of your readers to know that some boucherised poles, dated 1864, are still in existence in my division, and are sound. A large number bearing that date are, however, about to be renewed. Mr. R. S. Culley in his letter (page 232) was right in not considering boucherising a failure.

F. T. J. Haynes,
Divisional Telegraph Superintendent G.W.R.

Taunton, *November 13th*, 1895.

COST OF STEAM POWER.

Dr. Emery may be termed the exponent of steam-power in America as against water-power, not that he has any particular dislike of water-power so much as that he has a strong bias in favour of steam, and acts somewhat as a corrective in cases where water-power is being unduly pushed. Where fuel is cheap, it is very easy to spend more in the construction of dams and fluming than is warranted, especially in a country like America, where the severity of the northern winters may entail much trouble and frequent stoppages, and where something in the way of a steam boiler is after all required as a part of heating apparatus. Writing in the *Western Electrician*, he refers to what he has previously written on the subject of cost of steam-power on the basis of ordinary condensing engines in typical cotton mills; again, on assumed units of 500 horse-power with various types of engine. He now discusses the question in view of the supply by large units from Niagara and other water-powers, and asks what would be the cost of similar powers with steam? With large units the machinery can be of the best, and the cost of superintending can be minimised, while, if needed, units of 10,000 or 15,000 horse-power can be used, as already safely done in steamers, though he looks on such units as too big at present for use on land. Seeing there must be at least one spare unit, it would be unwise to divide a total power of 20,000 between two units, as this would demand a spare unit of 10,000 horse-power, and he suggests nine units of 2,500 H.P. each for such a power, all alike, and interchangeable.

For variable loads the cost of a horse-power will be greater than for steady load, and the latter case is considered first, in the form of an estimate, on the assumption that 20,000 H.P. can be sold per hour the year through. The basis of cost is coal at $2.24 per ton (say 9s.), and 1·25 lb. of coal per I.H.P. hour. The yearly cost of coal is thus made out as $546,814, divided into coal 43·4 per cent., the engine efficiency being 92·3 per cent., labour 11·1 per cent., supplies and repairs 19·2 per cent., interest, taxes and renewals 26·3 per cent.

This works out at $27.34 per horse-power year, or if 5 per cent. be added for dividends, and $1 for business expenses, to $31.94, or nearly £6 10s.

If 10 per cent. be charged on the orignal cost, the annual cost comes out as 35·54 dollars per H.P., but this is lower than it is probable can be accomplished under commercial conditions; for though engines have been made to work under 12 lbs. of steam, and boilers to evaporate 10 lbs. of water, the regular accomplishment of this is doubtful, for Dr. Emery considers large slow-speed engines must be employed for such work, and there are frictional losses to allow for. In the figures given, the number of hours in the year is taken as 8,760. Labour is taken out at—eight engine men, $2.00 per hour; 14 firemen and three assistants at $3 40 per hour, or a total of $5.40 per hour for labour. In addition, a chief engineer, three assistants and clerical help, would absorb $1.50 per hour, or a total pay-roll of $6.90 per hour, not including, we suppose, directors fees.

Supplies and repairs are estimated on the basis of the Fall River Cotton Mills, which show $\frac{8}{10}$ths of a mil. per H.P. hour, and this is reduced to 0·6 mil. for the heavier plant. Ten per cent. is estimated as the basis of renewals, insurance, &c. As regards the actual cost of the plant, it is considered probable that steam plant can be purchased for $30 per H.P., but with land, foundations, buildings, chimney and pipe connections, the cost cannot be less than $64 per horse-power, and in this way the 22,500 H.P. (including one spare unit of 2,250) will cost $1,440,000, on which is estimated, as above, 10 per cent. for interest and renewals, taxes, &c., or $144,000, being 26·3 per cent. of annual cost. The horse-power sold obviously costs $72, seeing that an eighth of it is idle. In this way the $27.34 plus 5 per cent. of $72 plus $1, adds up to the total annual cost of $31.94, or with 10 per cent. to the figure $35.54.

So much, then, for continued hourly work. For variable load, however, the case is altered very considerably, and Dr. Emery then proceeds to calculate the costs on an estimate of varying load.

(*To be continued.*)

BUSINESS NOTICES, &c.

Agency.—Messrs. Musgrave Bros., hydraulic and general engineers, of Leeds, have appointed Messrs. Julius Harvey & Co., of 11, Queen Victoria Street, E.C., as their representatives for London and district, for the home and foreign trade.

Asbestos Fuses.—A correspondent asks who makes asbestos fuses? Perhaps some of our readers may be able to give the information.

Business Announcements.—A statement having been circulated that Mr. W. C. Boulton had discontinued to represent Messrs. Illingworth, Ingham & Co., manufacturers of casings, of London and several provincial towns, he asks us to announce that the statement is totally incorrect.

We understand that Mr. H. R. Wood has left Messrs. B. Verity and Sons, and that Mr. Russell (formerly second engineer at their Birmingham branch) has succeeded him in the London management of their electrical accessory business. Mr. Allison, late of the P. & O. Steamship Company, has been appointed second engineer to the Birmingham engineering branch.

Catalogue.—A new and copiously illustrated catalogue issued by the International Electric Co., of 55, Redcross Street, Barbican, is before us. Glancing through the 200 pages with their numerous well-cut illustrations and thousands of prices, we observe that the company gives a great deal of attention to the production of telephones, bells, indicators, batteries, switchboards, lamps, as well as to telegraph instruments and electro-medical apparatus. Each section contains a good deal of valuable information and the articles are so described that as well as being a handy book of reference for electrical engineers it will be useful to the architect and contractor as a guide-book. The telephonic section has been compiled with special care, showing numerous novelties, and contains two photographic prints of telephone exchanges as fitted up by Mix & Genest, Limited. A number of estimates and 66 clearly designed diagrams

for bell and telephone installations of various requirements are specially useful, and the index appended facilitates reference to any article. We are pleased to congratulate the company upon turning out an excellent catalogue, neither time nor expense appear to have been spared to make it such.

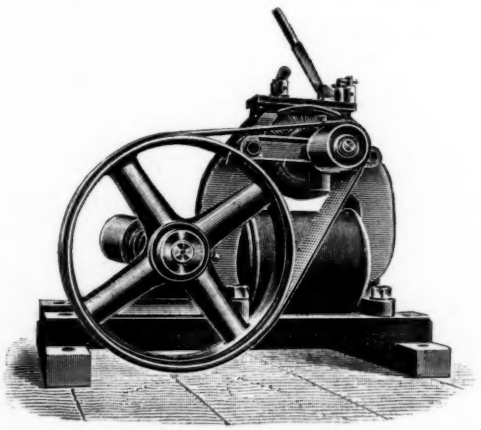
Edison & Swan United Electric Light Company v. Dale.—This matter came on for hearing before the assistant judge at the Mayor's Court, in the form of a judgment summons. The defendant, an electrical engineer, carrying on business at Dyer's Buildings, Holborn, said he was very much pressed by creditors at the present time. Eventually, with the defendant's consent, an order was made for the payment of £1 in 14 days, and the balance by instalments of 15s. per month.

La Marque Georges Richard.—Messrs. F. M. and George Richard are at present forming a joint stock company to be known as "La Marque Georges Richard" for extending the manufacture of cycles. The object of the new company is the construction and the sale of self-motive cycles and carriages. The promoters hope when the improvements will allow of it, to make an interesting application of electric propellers, either to cycles for individual locomotion, or to horseless carriages.

Presentation.—On Saturday evening, the 9th inst., a large number of the staff and workmen of Ernest Scott & Mountain, Limited, met at Newcastle, for the purpose of presenting Mr. M. B. Mountain, their works manager, with a small token of their esteem for him on the occasion of his marriage. The present consisted of a silver set of desert knives and forks, a silver set of fish knives and forks, and also a small spirit case.

Removal.—Messrs. King, Mendham & Co. finding larger premises necessary for the carrying on of their business, have now taken extensive premises at 10, Victoria Street, Bristol, which will shortly be opened with a large stock of fittings and apparatus for experimental use, as well as for the practical application of electricity.

Speed Reducing Gear for Electro-Motors.—A drawback to the use of small electromotors for industrial purposes has hitherto been the high rate of speed at which they revolve. This necessitates the addition of some form of gear for reducing the speed to that suitable for the machine to be driven. The ordinary countershaft as used in machine shops is heavy and ill adapted for the purpose, having to be fixed to the wall or ceiling. Worm gearing at once suggests itself, but if properly made is very expensive, and unless carefully constructed, highly finished, and run in an oil bath, the loss of power is considerable. Spur gearing is prohibitive on account of the noise when running at high speeds. Messrs. Cuttriss, Wallis and Company, Limited, are now supplying reducing gear, which is claimed to be simple, light, self-contained and noiseless. It consists of a



strong oak frame, to which the motor is bolted, a simple, adjustable bracket carrying a light shaft with two pulleys and an endless leather belt. The success of the gear is due in a large measure to the belt, which is made of specially prepared leather of the finest quality, insuring great flexibility with practically no stretch. The joint is carefully cemented and will bend as freely as the remainder of the belt; jarring and slips are thereby avoided. The great flexibility of the leather enables a belt of unusual width (some two or three times that in common practice) to be made use of. The requisite grip on the small pulley of the motor is thereby obtained without any strain on the bearing. When an exceptionally low speed is required another set of pulleys is fitted on the other side of the motor, thus giving a double reduction without very materially increasing the bulk of the apparatus.

The New Lamp Works at Kempston.—During last week some of the plant required for the works of the Crystal Electric Lamp Company, to which we have already referred, was put in position. A large alternating dynamo, weighing nine tons, was considerably damaged in transit on the London, Brighton and South Coast Railway, and this will necessarily somewhat retard operations at the works, as it is stated to be practically useless.

The Electrical Power Storage Company Limited v. Young.—This judgment summons came on for hearing at the Mayor's Court, before the assistant judge. The defendant said he had not had any dealings with the plaintiffs since 1894. The goods for which he was sued were supplied to the J. L. Young Manufacturing Company, Limited, in whose employ he was. He produced the invoice for the goods, which were debited by the plaintiffs against the company. The plaintiffs' solicitor said that invoice was sent to the company in mistake. The defendant made a long statement to the Court, in the course of which he said he had been compelled to close his business owing to proceedings being taken against him by certain "legal brigands." His Lordship said it was a case for further enquiry, and eventually the case was adjourned.

ELECTRIC LIGHTING NOTES.

Ashton-on-Mersey.—The electric lighting order is to be put into force. According to a Manchester newspaper an agreement is to be arranged between the Council and the Altrincham and District Electric Supply Company.

Asylum Lighting.—The Metropolitan Asylums Board has added the name of the Brush Electrical Engineering Company to the list of firms selected to tender for the electrical portion of the work in connection with the installation of the electric light at Brook Hospital.

Bangor.—The electric lighting question came up again last week. A councillor tried to pass a resolution rescinding the motion deciding to carry out an electric lighting scheme and to engage the services of Mr. F. H. Medhurst. He was unsuccessful, eight voting for his motion and 13 against. The scheme therefore goes forward.

Blackburn.—From 63 applications for the appointment of assistant electrical engineer, Mr. Smythe has been selected and his appointment confirmed by the Council.

Cardiff.—The members of the Engineering Society of the University College, Cardiff, inspected the electrical plant at the station in Canton on 7th inst.

China.—The *China Gazette*, speaking of the growth of electric lighting in Shanghai, says: "A couple of years ago there were only about seven miles of streets lighted by electricity, for which 60 arc lamps were quite sufficient, and there was not a single incandescent lamp in or around Shanghai. Now the electrical department of the Municipal Council runs 140 arc lamps, lighting some 15 miles of streets, and there are about 43 miles of line wire laid, in addition to 6,100 incandescent lamps, of 8 candle-power each, for domestic purposes. The customers for incandescent lighting have increased from one to 55 in number since the Council took over charge of the department."

Dewsbury.—The capacity of the existing electric mains across Nelson Street being inadequate, the electrician has been instructed to lay mains there of an increased sectional area.

Eccles.—It is stated that the majority of the ratepayers are opposed to the electric lighting scheme, and the whole matter is to be considered by the new Electric Lighting Committee.

Harwich.—The Corporation has adopted a scheme under which the Town and Village Electric Light and Power Company, Limited, will take over the provisional order granted to the Municipal Council for the electric lighting of the town. Both public and private lighting are to be introduced.

Hastings.—Mr. Andrews, of the Hastings Electric Lighting Company, in a communication to the local Press, publishes details regarding a report of Mr. A. P. Trotter upon various photometric tests made at Hastings for the directors of the company. The report, which contains a description of the methods employed for making the tests, and gives tabulated results obtained from various burners, both gas and electric, is to be published in pamphlet form.

Huddersfield.—There are 252 consumers now connected with the mains, having lamps fixed equivalent to 18,500 of C.P. The mains have been extended along Acre Street and Victoria Lane, Lindley, and are now being carried through Lindley to supply several large consumers. The mains have also been extended along Greenhead Road, Fitzwilliam Street, Manchester Road, John Street, and Queen's Road. Generating plant, ordered in June from Messrs. S. Z. de Ferranti, Limited, capable of supplying 8,000 8-C.P. lamps, is expected to be running in about a fortnight. This will enable the department to supply those consumers who, owing to the existing generating machinery being overloaded, have been kept waiting. The cost of producing the energy has during the year been reduced in a most satisfactory manner, owing to the increased demand and economies effected.

Ipswich.—The County of London and Brush Provincial Company are anxious to secure a provisional order for Ipswich, and Mr. Paris interviewed the Paving and Lighting Committee a few days since to ascertain whether or not the Council intended to oppose their application. Mr. Paris has to present some further information to the Committee before anything is decided.

Dundee.—The Harbour Trustees are considering the advisability of lighting the river buoys by electricity. A special installation is contemplated, instead of supply being taken from the Corporation mains.

London.—Mr. L. C. H. Mensing has secured the contract for fitting a large number of lamps—arc and incandescent—into the premises of Messrs. Fred. Watson & Co., in the Seven Sisters Road, N., also the contract to instal a number of incandescent lamps at the premises of Messrs. Bowman & Crowhurst, in Queen Victoria Street, E.C., as well as a number of other similar contracts.

Limerick.—A Committee of the whole Corporation is to consider the proposed electric lighting scheme.

Manchester.—A correspondent of the *Manchester Guardian* states that there was an explosion in an electric lighting main box in Cross Street on 6th inst., the manhole cover being blown off.

Monmouth. — Councillor Wm. Honeyfield has been elected Mayor for the fifth consecutive year. It is considered only right that he, having championed the electric lighting and sewerage scheme, should be Mayor when those undertakings are inaugurated, which may be very shortly.

Mill Lighting. — In 1889 an installation of 2,000 16-candle-power incandescent lamps and 40 1,000-candle-power arc lamps was fitted up at Manningham Mills. This has proved so successful that the management is now engaged in completing the lighting of the mills by electricity, which will require the addition of 2,700 16 candle-power lamps. The installation has been designed by Mr. Edwin Preece, and fitted by Messrs. Thomas Preece & Co, Bradford. Engines of 600 H.P. will be used with the current at 220 volts, the lamps being arranged on the parallel system. When completed, the installation will be one of the largest of a private character in England.

Neston.—A report has been presented by Mr. Marsh, consulting electrical engineer, regarding a proposal to light the district by electricity. His recommendations are as follows:—High tension alternating system; district to be divided into three separate circuits, Neston, Parkgate, and Little Neston; private and public lighting suggested; two 50-unit dynamos and two 100-H.P. boilers, each set capable of supplying about 1,000 16-C.P. lamps; 80 lamps for street lighting (as against 60 gas at present); cost, about £6,000, exclusive of buildings. Estimates are given of anticipated income, &c. A public meeting was held on Wednesday night to consider the question.

Oldham.—The Wright system is to be adopted in connection with the Oldham electricity supply, the change to come into operation on March 25th.

Paisley.—The Caledonian Electric Supply Company, Limited, has notified the Council of its intention to apply for a provisional order for lighting the district.

The Clark Town Halls, Free Library and Museum is to be lighted by electricity, and Dr. Bottomley has been engaged to act as consulting engineer in connection with the work.

Provisional Orders.—The *London Gazette* contains notification of applications to be made during the 1896 Session for provisional orders for electric lighting for Godalming Corporation, Middleton Corporation, and Bath Urban Sanitary Authority, also Wells Corporation.

Rotherham.—A committee of the Corporation is to consider the question of electric lighting and tramways.

Runcorn.—Before the District Council applies for provisional order, a committee is to inquire into the probability of the powers being taken advantage of.

Sale.—The Council has resolved to apply for a provisional order, and to oppose the application of the Altrincham Electric Supply Company, Limited.

South Africa.—In reference to the paragraph in our last issue, we now learn that the "Brockie-Pell" arc lamp has been selected by the Sanitary Board for the lighting of Johannesburg, an order for upwards of 50 lamps having been placed with Messrs. Johnson & Phillips.

Spain.—A company is in course of formation in Zarraga, the object being to establish and operate a central electric lighting station in the town. Tenders have just been invited for the establishment of a central station in the town of Pilona (Oviedo). The little town of Leanes is now lighted by electricity. An electric lighthouse is approaching completion at Cabo Villano (Galicia).

Stapleton.—The District Council has approached the Barton Regis Guardians asking them to consider the question of lighting the workhouse premises by electricity. They are making enquiries as to lighting the district by electricity, and desire to know whether the Barton Regis Guardians would favourably consider the lighting of the Union House from the plant proposed to be laid. The Guardians have replied that the present is not a time for such expenditure.

Wakefield.—A recent meeting of the Tradesmen's Association unanimously expressed satisfaction with the action of the Council in taking the electric lighting question in hand.

York.—The City Council are moving in regard to electric lighting, and are inquiring Prof. Kennedy's fees.

Weybridge.—A committee has been appointed to confer with Mr. Martindale as to the transfer of the provisional order from the Weybridge Electric Supply Company to the Council.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Blackpool Tramways.—It will be remembered that the original line along the Promenade was stopped for reconstruction of the conduit during the early portion of 1894, but running was resumed at the beginning of the season, and has continued from that time forward. The Lytham Road section of the tramways, authorised by the Blackpool Tramways Order of 1893, was, however, completed ready for running about a month or six weeks ago. On this section, which branches off from the Promenade at the Manchester Hotel, the conduit system is used as far as the South Shore Station, and from this to the end of the Borough horse traction is employed. There are other sections of line authorised in the same Act which are not yet completed, and we understand that the section beyond the South Shore Station to Borough boundary is intended to be ultimately run on the overhead system.

Derby—Ashbourne Light Railway.—Plans of this proposed new light railway have just been completed. Levels of the roadway have been taken, and the usual Parliamentary notices will be published very shortly. The Bill for the construction of the new line will be deposited in Parliament at the earliest possible moment.

Dover Proposed Electrical Tramways.—The Corporation has passed a resolution applying to the Board of Trade for the necessary powers to enable them to construct electric tramways throughout the borough, the majority of the main streets being scheduled. At Sandwich negotiations are being carried on by the town surveyor with the land owners for the construction of a tramway to the seaside, a distance of two miles.

Dublin Tramways.—The directors of the Dublin United Tramways Company have just returned from New York, where they have been inspecting various street railway systems. They reported, in the course of an interview, in favour of the overhead system as the most practical, and hope to be able to convince their shareholders and the public that accidents have not been more numerous during the use of the trolley system than under the old system, taking into consideration the increased proportion of passengers.

Electric Traction in Austria and Hungary.—A preliminary concession has been granted for a projected electric tramway between Rosenburg and Zwette, in Lower Austria. Concessions have also lately been granted for the construction and operation of several lines of electric tramways in the town of Linz. The question of electric traction is also being considered at Izegedin.

Electric Traction in Switzerland.—An electric tramway is to be constructed between Aubonne and Allaman. The question of electric traction is under consideration at Fribourg. It is proposed to construct an electric tramway between Coire and Passugg (Goisons). The Molard-Carouge and the Molard-Moillesulaz horse tramways at Nyon are to be converted into electric lines.

Electric Traction in the Dutch East Indies.—An electric tramway is to be constructed between Batavia and Bantam, in Java, a concession having lately been granted for the same.

Electric Traction and the Copper Market.—A copper circular, just issued by Messrs. Houston & Co., of New York, states that they expect that the development of electric traction in Europe will soon be an important factor in the future of copper consumption. They mention that a syndicate with $1,900,000 of capital proposes to construct 84 miles of electric tramways in Japan, where already a 12-mile road is working satisfactorily.

Newcastle Tramways.—The tramway question is up for consideration at Newcastle. It has been decided by the City Council that a Bill be promoted in Parliament for the construction of tramways; the doubling of certain existing tramways; the working of the said intended tramways and of all or some of the authorised tramways of the Corporation by means of ropes, cables, or wires; the working of all or some of the tramways of the Corporation (except the Westgate Road, Arthur's Hill, Elswick Road, Scotswood Road, and Byker tramways) by electricity or other motive power; the running of carriages upon the said intended tramways, and the taking of tolls and charges for the use thereof; and other powers.

Proposed Electric Tramway for Dundee.—One of the Harbour Trustees urges the need for a tramway to the jetties, and suggests the adoption of electricity as the motive power.

Swansea Tramways.—The tramway system is to be bought over by the Corporation at a cost of £32,000. The proposal to run it by electricity embodies the use of 20 motor cars at a cost of about £1,000 each.

Tramways for Persia.—A despatch from Teheran says that Herr Felix Morals, a German subject, has been granted a 75 years' concession for the construction of a carriage road from Teheran to Bagdad, and for the establishment of a transport service. He has also obtained a 90 years' concession for a steam or electric tramway, about 10 miles in length, from Teheran to the villages north of the city.

TELEGRAPH AND TELEPHONE NOTES.

The Trinidad Dispute.—*Commerce* of the 8th inst. says:—"And so the momentous question as to the ownership of the Trinidad rock in the Southern Atlantic is, after all, only a matter of possible antagonistic telegraphic interests. Neither Great Britain nor Brazil would ever have troubled about this microscopic barren island had not Sir John Pender's plans in Brazil happened to look like being upset. He thereupon very naturally thought of having a direct cable to the Plate. Trinidad would have been useful, and the British Government, whose purposes would also have been suited, took possession of, and still retain the island. Brazil, of course, promptly put in a claim to it. Now the question really is, not what negotiations have been going on between various cable companies and the Brazilian Government, but simply: 'To whom does Trinidad belong?' It certainly appears to have been unknown in Brazil until the rival cable was suggested. Other interests, however, than the present telegraph companies' dispute militate in favour of Trinidad's retention by the British Government. A direct British cable to South America would be desirable, were it only to assure that messages could be transmitted, in spite of the periodical revolutions of the South American Republics. A fair specimen of the results of these interesting little events was furnished by Brazil herself during the recent rebellion, when all cables were stopped. In any case, now that the question of the possession of Trinidad has been raised, it is to be hoped that it will be settled on its own merits, and not on those of the telegraph dispute."

Telegraphic Communication with Glasgow.—At a meeting of the directors of the Glasgow Chamber of Commerce on Monday, a letter was read from the Postmaster-General regretting delay—due to the recent remarkable and altogether unforeseen increase of telegraphic business—in the transmission of messages between Glasgow and London. Additional wires could only meet the increase, but the distance involved great expense. The Postmaster-General, the letter added, was making provisional arrangements to improve the service. The Chamber, however, regarded the communication as unsatisfactory, there still being great delays.

The Proposed Canadian-Australian Cable.—From the *St. James's Gazette* we learn that Mr. Chamberlain has placed himself in communication with Sir Charles Tupper and the Agents-General for the Australian colonies on the matter of the proposal to lay a Pacific cable connecting Canada with Australia, and thus afford cheaper and quicker communication between England and her colonies. The Agents-General will have an interview with Mr. Chamberlain on the subject at an early date, probably in the course of a few days.

CONTRACTS OPEN AND CLOSED.

OPEN.

Blackburn.—November 30th. The Corporation invite tenders for alternators, transformers, switchboards, &c.

Belgium.—January 15th, 1896. The Belgian Minister of War is inviting tenders for the contract for an installation of electric lighting in the new military school in the Avenue de la Renaissance in Brussels. Tenders to the Ministère de la Guerre, Brussels.

Chili.—December 5th. Tenders are invited for the manufacture and laying of a submarine telegraph cable from Puerto Montt to Punta Arenas. The conditions and specifications may be consulted in the Chilian Legation, Member's Mansions, 36, Victoria Street, S.W.

Derby.—November 19th. The directors of the Midland Railway Company are prepared to receive tenders for the supply of stores for 1896, including the following items:—Copper and brass tubes, &c., engine fittings (brass), telegraph instruments, telegraph stay rods, bolts, &c. (galvanised), telegraph and signal wires, gas tubes and fittings (iron), gas fittings (brass), Indiarubber brake pipes, washers, &c. Particulars from Mr. G. Morrall, the General Stores Department, Derby.

Durban.—November 27th. Tenders are at present being invited for No. 40 cast-iron service-boxes for connections from concentric mains, No. 120 cast-iron service-boxes (or handholes) for house connections, No. 60 cast-iron junction-boxes for arc lamps, No. 70 cast-iron manhole frames and covers, and No. 60 ornamental cast-iron arc pillars, 25 feet high, for the Corporation of Durban. Details from the consulting engineer, Mr. W. H. Radford, C.E., Pelham Chambers, Nottingham, on deposit of £2 2s. Tenders to be delivered in London by 27th inst.

Fermoy.—The Town Commissioners are inviting tenders and schemes for electric lighting the town (public and private).

Kassel.—Tenders are invited for the supply of six automatic water-level indicators, with electric alarms. Pneumatic apparatus preferred. Particulars from and tenders to Das Hauptbauamt der Fuldakanalisirung in Kassel, Lutherstrasse 5 II.

London.—November 18th. From last week's Official Notices will be gathered information regarding tenders invited by the Metropolitan Asylums Board for wiring and other electric light work at the Brook Hospital and Ambulance Station, Shooter's Hill.

Swansea.—December 6th. Tenders invited for supply and erection of plant for electric lighting and dust destruction for the Corporation. For further details see our "Official Notices."

Windsor.—January 1st, 1896. The Corporation invites proposals for taking over and working their electric lighting orders. All proposals to include the erection and maintenance of a generating station upon a specified site, laying down mains, and necessary equipments, with a constant supply of electricity for lighting purposes in the stated area. Details to be obtained from the Town Clerk, Windsor.

Warrington.—November 30th. The Cheshire Lines Committee invite tenders for the supply, during the year 1896, of various stores, among which are the following items:—Iron bars, sheets and plates, spike iron, &c.; telegraph materials, instruments, wire, &c.; wrought-iron tubing, point rodding, point rollers and standards, lead piping, and sheet lead; wrought-iron bolts, chain, &c.; galvanised sheets, signal wire, pulleys, stay-rods, screw-spikes, zinc sheets, &c. Particulars from Mr. Saxon Barton, storekeeper, Cheshire Lines, Warrington.

York.—November 26th. The North Eastern Railway are prepared to receive tenders for telegraph apparatus and telegraph wire and line stores in such quantities as they may require, during the six months ending June 30th, 1896, delivered carriage paid at the company's telegraph stores at York. Particulars on application to Mr. Graves, Telegraph Department, York.

CLOSED.

Burslem.—Messrs. Crompton & Co., Limited, have secured the contract for lighting the public baths by electricity for £213.

Dewsbury.—The following tenders were submitted for wiring the Corporation public baths and library. Mr. John B. Mitchell is the borough electrical engineer whose inclusive estimate was £393:—

	£	s.	d.
G. A. Steinthal, Bradford (accepted)	284	0	0
A. R. Turner, Dewsbury	295	0	0
J. A. Edmondson, Leeds	307	1	6
Maunsell, Mercier & Co., Manchester	346	14	0
A. Sykes, Huddersfield	392	0	0
Lomax, Kendal & Co., Manchester	405	0	0
Paterson & Cooper, London	424	15	0
A. Hirst & Son, Dewsbury	424	16	0
Fowler, Lancaster & Co., Birmingham	482	0	0
Northern Counties Electrical Construction Co., Manchester	641	0	0
Howe Electrical Engineering Company, Liverpool	895	0	0

France.—The General Direction of the French Posts and Telegraphs has just given out contracts for the supply of the following:—To M. Defuisseaux, of Baudour, Belgium, for 80,000 porcelain insulators; to Veuve de Fenoyes, of Ste Foy l'Argentière, for 80,000 porcelain insulators; and to Messrs. Hache & Co, of Vierzon (Cher), for 150,000 porcelain insulators.

St. Marnoch's.—The contract for the electric lighting and pumping plant at St, Marnoch's, Co. Dublin, to the specification of Mr. Morgan Williams, C.E., has been placed with Messrs. Edmundson, Limited, of Dublin. The motive power is to be derived from oil engines.

NOTES.

North-East Coast Institution of Engineers and Shipbuilders.—Yesterday evening, 14th inst., a paper on "Alternating Current Motors for Use on Single Phase Mains" was read at Newcastle by Mr. John B. Bent. The following is the synopsis of the paper:—

DIFFICULTY OF PROBLEM.

Alternating current motors may be divided into three divisions:—

(1) Those with constant fields.
(2) Those with alternating fields.
(3) Those with rotary fields.

Class (1).—Ordinary alternators will run as motors, but require starting and separate exciter—Not suitable for small powers.

Class (2).—Ordinary series motors with laminated fields—Difficulties arising from self-induction and phase complications—Sparking and heating of armature coils—Attempts made to remedy these defects.

Class (3).—Rotary field motors—Theory of rotary fields—Effects of capacity and induction in altering phase. General points in design—Starting and current splitting devices.

Tables of efficiencies.

On December 17th, at Sunderland, Mr. J. M. Allan will read a paper on "An Investigation into the Forces Tending to Produce Vibration in High-Speed Engines."

Mr. Franklin Pope's Accident.—A thorough investigation into the causes of the death of Mr. Pope by electrical shock has been made by Messrs. Edward Weston, William Stanley, and George A. Hamilton. In their report they state that their investigation discloses the fact that Mr Pope met his death by reason of the existence of one or more grounds on the primary or main distributing lines of the system, and if this had not been the case he could not have received the fatal shock. The facts developed by the examination and study of the whole of the conditions in this case demonstrate :—

First—That no matter how skilled a man may be or how much knowledge he may possess of the principles and mode of operation of electrical apparatus of this character, it is not safe to place converters inside of buildings without providing absolutely effective means of preventing access to them before the primary or main line current is turned off.

Second—No one should ever be permitted to handle or touch a converter, or the wires leading to and from it without first turning off the current from the primary or main line circuit.

Third—Effective indicating devices and alarms should be placed on the primary lighting wire circuits to call immediate attention to existence of grounds on the line, and when such an alarm or indication is given the location of the ground should at once be determined and the ground connection removed at once.

Fourth—Daily tests should be made of the condition of the lines to determine their approximate insulation resistance, and records of such tests should be preserved from day to day so that any deterioration of the insulation resistance of the lines would be discovered.

Fifth—That all overhead high pressure lighting wires should be provided with guard wires situated above the lighting wires so as to prevent other wires from falling on and making contact with the lighting wires, and thus making grounds. If such guard wires be connected at intervals to the earth they will serve to protect the lighting wires to a large extent from the effects of lightning.

Sixth—That telegraph and telephone wires should always be placed below the lighting wires and should be so run as to prevent as far as possible interference with the lighting wires in case the telegraph or telephone wires break and fall.

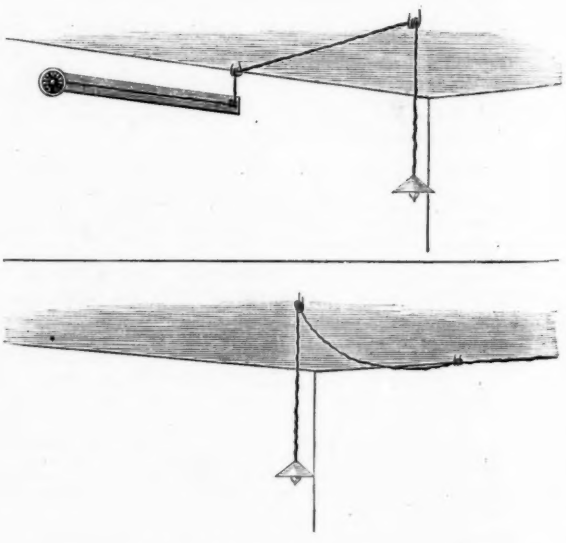
Criticism of Electro-Magnetic Railways.—Electro-magnetic railways are causing some amount of controversy in America. Mr. James H. Bates, in the New York *Electrical Engineer* of October 30th, replies to a previous letter of Mr. Johnson who upheld the magnetic system. Mr. Bates refers to the great trouble electro-magnets give in telegraph work, and says if "electro-magnets are going to give all this trouble in telegraphy, how much more will they give when subjected to the vastly more exacting service of a closed conduit electric railway with much traffic? These difficulties will not only be more than proportional to the traffic, but very much enhanced by other factors pointed out below. . . . . Electro-magnetic switching devices have been tried and abandoned by many inventors, and their testimony has invariably been, in the words of Mr. Albert Stetson (before the American Institute Electrical Engineers, December 20th, 1893), 'they have proved a constant source of trouble. . . . All of us who have had any experience with electro-magnetic switching devices know that the less number we have of them the better they work.' The success of the closed conduit system depends upon finding an effective and safe mechanical switching device; unless this can be found there is no hope for it. I have in mind several street car companies who have taken the overhead trolley, open conduit or even storage battery, instead of the magnetically switched surface system simply for these reasons. If an electro-magnet is the 'most reliable thing in the physical world,' why is it not used on each individual car as a cut-out instead of a fuse? Its use for this purpose has often been seriously discussed. If it gives too much trouble for such service, what chance would it have to meet the exacting conditions already spoken of? Any street car man knows that these statements are mild compared with facts."

Institution of Electrical Engineers.—We are informed by the secretary that the annual dinner, which was to have taken place on Friday, November 29th, has been postponed until Friday, December 13th, when H.R.H. the Duke of Cambridge will honour the Institution with his company. A circular to the above effect is being issued to the members. At the first meeting of the present session, on Thursday, November 28th, the following papers will be read :—"The Electric Wiring Question," by F. Bathurst, Associate; "Concentric Wiring," by Sam Mavor, Member.

Royal Society.—The following have been recommended by the president and council of the Royal Society for election into the council for the year 1896, at the anniversary meeting on November 30th :—President, Sir Joseph Lister, F.R.C.S., D.C.L.; treasurer, Sir John Evans, K.C.B., D.C.L., LL.D.; secretaries, Prof. Michael Foster, M.A., M.D., Lord Rayleigh, M.A., D.C.L.; foreign secretary, Mr. Edward Frankland, D.C.L., LL.D.; other members of the council, Mr. William Crookes, F.C.S., Sir Joseph Fayrer, K.C.S.I., Mr. Lazarus Fletcher, M.A., Mr. Walter Holbrook Gaskell, M.D., Mr. William Huggins, D.C.L., Lord Kelvin, D.C.L., Prof. Alexander B. W. Kennedy, LL.D., Prof. Horace Lamb, M.A., Prof. Edwin Ray Lankester, M.A., Prof. Charles Lapworth, LL.D., Major Percy Alexander MacMahon, R.A., Prof. John Henry Poynting, D.Sc., Prof. Arthur William Rücker, M.A., Mr. Osbert Salvin, M.A., Prof. Harry Marshall Ward, D.Sc., Admiral William James Lloyd Wharton, C.B.

Death from the Shock of the Electric Torpedo.—A writer in the New York *Electrical Engineer* has seen torpedoes and electric eels in the delta, better known as the Oronoco Valley, Venezuela. He saw a mule killed by an eel once, and saw a woman and a large boy, her son, about 18 years old, both killed by a torpedo. The two were on the bank of the lower Oronoco, below Ciudad Bolivar, and were killed by the same fish. In crossing ponds he has frequently seen mules knocked down by electric eels, which are quite numerous in that delta. He has seen them in pools dried up and in a decayed state, and no turkey buzzard would go near them. He could relate many queer stories about them if time and space would admit. Everybody is afraid of these electric fishes, and the turkey buzzard has no use for them.

Cheap Wiring.—There are many ways of cheapening the introduction of electric lighting. We illustrate one. For the benefit of those interested in cheap wiring, we would say that you simply take two wires, twist them together, tie one end to the street mains and then run them through the building, metal staples being used as support, till you arrive at the lamps when you merely fix them on. Our illustration



represents the actual wiring in a north country office. No casing is used at all. In some of the rooms the wires are allowed to droop, and no doubt if these were carefully garnished with ham frills they would make graceful festoons. Yet we have fire offices and an institution which are putting themselves in considerable pain to devise rules for wiring.

Society of Arts.—On Wednesday, November 20th, at 8 p.m., will be held the first ordinary meeting of this Society. The opening address will be delivered by Major-General Sir John Donnelly, K.C.B., Chairman of the Council.

Electricity and Health.—The report on the sanitary condition of the City for the past year has been submitted to the Commissioners of Sewers by the Medical Officer of Health (Dr. Sedgwick Saunders). The following comments extracted therefrom are very interesting :—The extension of installations of electricity marked a new era of sanitation, and much benefit must accrue to the moral and physical condition of the employees in large commercial establishments, who had hitherto been condemned to work long hours by day and night in gas-heated, ill-ventilated basements. At the end of the year there were nearly 3,000 private consumers of electricity, using upwards of 136,000 incandescent lamps, and 483 electric lamps were now placed in the principal streets, displacing 1,338 gas lamps.

Obituary.—We regret to learn of the death of Mr. George Edward Hartmans, M.I.E.E., aged 28, who, while delirious with typhoid fever, shot himself through the head at his home at 8, Woodville Road, Ealing, W. The deceased gentleman was engaged at the Great Eastern Railway Company's electric light station in High Street, Shoreditch. Our readers will remember the article on "Carbon Brushes for Heavy Currents," contributed to the Electrical Review for September 6th, 1895, by the late Mr. Hartmans, whose parents and friends have our sincere sympathy.

Mr. Ansell's Jubilee.—The 50th anniversary of Mr. W. T. Ansell's entry into the telegraph service was to be celebrated last night at the Holborn Restaurant. Mr. Ansell's long and honourable career, which almost covers the complete history of telegraphy, was deserving of some adequate recognition. Few men are now living who can claim to have been closely associated with telegraphy in 1845. That year, however, forms the first in the record of Mr. Ansell's practical connection with telegraphy. We offer him our sincere congratulation.

Society of Arts.—The following are among the lectures announced to be delivered before the Society of Arts after Christmas : — "The Making of a Great University for London," by Prof. Silvanus P. Thompson ; "Standards of Light," by W. J. Dibden, F.C.S. ; "Alternate Current Transformers," four Cantor lectures by Prof. J. A. Fleming, on January 20th and 27th, and February 3rd and 10th, 1896 ; "Applied Electro-Chemistry," four Cantor lectures by Mr. James Swinburne, on April 27th, and May 4th, 11th, and 18th, 1896.

Royal Institution.—The Christmas course of lectures, adapted to a juvenile auditory, at the Royal Institution, will be delivered this year by Prof. John Gray McKendrick, M.D., LL.D., F.R.S., Professor of Physiology in the University of Glasgow, and formerly Fullerian Professor of Physiology in the Royal Institution. The subject will be "Sound, Hearing, and Speech," and the lectures will be experimentally illustrated. The first lecture will be delivered on Saturday, December 28th, at 3 o'clock, and the remaining lectures on December 31st, 1895, and on January 2nd, 4th, 7th and 9th, 1896.

The Smithsonian Award for the Discovery of Argon.—Last week Lord Rayleigh and Prof. Ramsay had the cheque for $10,000 which had been awarded as the first Hodgkins Prize by the Smithsonian Institute at Washington for the discovery of Argon, handed to them at the United States Embassy in London.

Personal.—We are pleased to congratulate Dr. W. S. Hedley upon his appointment as medical officer in charge of the electrical department which has been formed at the London Hospital. The hospital authorities have done well in engaging a man so conversant with electro-medical science.

So pleased was Mr. Kiralfy with the electric lighting arrangements which Mr. Guy C. Fricker carried out for the Empire of India Exhibition, that he has appointed that gentleman to undertake a similar commission in connection with next year's show at Earl's Court.

The Institution of Civil Engineers.—This institution has just elected the German Emperor to its roll of honorary members. The nineteen others in this class in order of date of election are the Prince of Wales, the Duke of Coburg, the Duke of Connaught, the King of the Belgians, Sir Frederick Abel, Sir W. R. Grove, the Duke of Cambridge, Lord Kelvin, Sir Henry Bessemer, Lord Rayleigh, Sir Lintorn Simmons, the Duke of York, Sir G. G. Stokes, the Duke of Devonshire, the Marquis of Salisbury, Sir Douglas Galton, Dr. Edward Frankland, Mr. Octave Chanute (United States), and M. Henri Schneider (France).

English Tramway Enterprise.—It is said that the State of Massachusetts has a greater mileage of tramlines, the bulk of them electrical, than the whole of the United Kingdom, although its area is only about one-fifteenth of the latter, the population also being in about the same proportion. Let us hope that Mr. Garcke, and those associated with him, may speedily alter the condition of affairs.

The Institution of Junior Engineers.—To-morrow, Saturday, 16th inst., at three p.m., the members of this Institution will visit Messrs. Bell's Asbestos Works, Southwark Street, London.

NEW COMPANY REGISTERED.

British Electric Traction (Pioneer) Company, Limited (45,897).—This company was registered on November 7th with a capital of £100,000, in £10 shares, to enter into an agreement with the Electric and General Investment Company, Limited, and to carry on the business of carriers of passengers and goods, electricians, engineers, contractors, and manufacturers of railway, tramway and electric apparatus. The subscribers (with one share each) are:—C. R. Wilson, G.C.M.G., 16, Wilton Street, S.W.; E. Garcke, 1, Great Winchester Street, E.C., contractor; J. Raworth, 46, Christchurch Road, S.W., engineer; R. Doyle, 23, Pyrland Road, Highbury, accountant; G. Herring, 1, Hamilton Place, W., gentleman; J. C. Bull, Surbiton, secretary; J. B. Braithwaite, jnr., 27, Austin Friars, E.C., stockbroker. The number of directors is not to be less than three, no more than six. Qualification £500; remuneration as the company may decide. Registered office, 1, Great Winchester Street, E.C.

CITY NOTES.

St. James's and Pall Mall Electric Light Company, Limited.

The directors have issued a prospectus inviting subscriptions for an issue of £20,000 4 per cent. debenture stock at a premium of 2½ per cent. The list of applications closes to-day. This stock is secured by a trust deed as a first charge upon the freehold property of the company, consisting of Mason's Yard and Carnaby Street central stations, together with the fixed plant at those stations respectively, and the company's mains, and also upon the securities representing the £15,000 capital reserve fund, and as a floating charge upon the whole undertaking of the company generally. The debenture stock will be registered, and will be redeemable at par at any time after the first day of January, 1914, or at any time previously to that date, on six months' notice, at a premium of 5 per cent. The prospectus gives figures showing the capital expenditure up to December 31st, 1894, also the net revenue of the company for the past four years, the average being about £12,250 per annum.

West India and Panama Telegraph Company, Limited.

At the meeting held at Winchester House on Wednesday, Mr. C. W. Earle presided, and moved the adoption of the report and accounts. This was the fourth consecutive report, he said, in which the board had had to announce a reduction in the traffic receipts for the half-year, as compared with the corresponding previous six months, although every station had been in communication, and the service had been carried on as perfectly as usual, and without complaint. No doubt the unfortunate state of the West Indies in regard to the low price of sugar had very much prejudiced the receipts. But in seeking to be quite certain as to what was the real cause of the depreciation, he had taken some trouble to look into the traffic accounts, which were divided into two heads—first, the international traffic—the messages coming on to or going off from the company's lines from

or to other lines; and secondly, the inter-colonial traffic between the different colonies served by the company. He found that whereas in 1885 the inter-colonial traffic amounted to £15,722, during 1894 it only amounted to £8,644, showing a reduction of nearly 50 per cent. The international traffic of 1894 was only about 9 per cent. less than that of 1885. It was quite fair to assume that while the company's traffics were affected by the general decline of commercial prosperity in the West Indies, it would have affected both classes of business; but from these comparisons it appeared that it was the inter-colonial traffic that had been so much depreciated, and he was informed that the reason for this falling off was the great increase in "tramp" steamers which plied now through the West Indies. In former days the inter-colonial traffic had mainly to do with messages connected with the chartering of ships; now, no doubt, the merchants who had a cargo to send away waited for the call of some of the tramp steamers, who came in and plied for freights very much as we saw cabs "crawling" about the streets of London for fares. He had no doubt in his own mind that this had caused a great deal of the falling off in the company's inter-colonial traffic. It was fair to ask what the directors were going to do to remedy such a state of affairs. They had prospected all the West Indian shores for traffic to feed the system; and they had sent their general superintendent to various places to interview the merchants and others. These merchants, though delighted with the idea of having the telegraph laid to those places, were honest enough to say that they did not expect to find much use for it; and when the question was mooted whether the Government would not give a subsidy or guarantee, the answer was, "No doubt they would be delighted; but whether they would pay you or not is another question." After receiving these chilling accounts, the directors thought it better to leave the matter where it was. With regard to the accounts, there was very little, as usual to say. The charges were almost all on the same scale and lines as they had been for years. The whole balance of revenue over expenditure was about £18,000, as compared with £16,000 last year, and, so far, might be considered fairly satisfactory.

Mr. William Andrews seconded the motion, and it was unanimously carried.

Western and Brazilian Telegraph Company, Limited.

The half-yearly meeting of this company was held yesterday.

Mr. Andrews, the chairman, said the period under review had been fairly satisfactory. The internal traffic had been larger than the international traffic. The receipts from the new line promised to continue at a satisfactory rate of progress. Looking at reductions, the net outcome was rather encouraging. If they had a satisfactory exchange they would be in a fairly good condition. The chairman then went into the accounts in detail. With regard to the position of purchasing the company's lines, the right of the Brazilian Government to purchase these lines would have expired this year, but the Government have applied for an extension of time, and they would no doubt secure it. Things had come to a standstill now. A new company had been formed to connect the great ports of the Amazon. This line was being rapidly completed, and all apparatus was being pushed forward. When this work is completed, it will be a valuable feeder to the Western Company's lines. There was one subject he would have preferred to leave untouched. Shareholders had seen the speech of the chairman of the Brazilian Submarine Company and discussion in the newspapers with regard to the laying of the cable which touched Trinidad. The Brazilian Company could have no lot or part in the laying of the cable in the area of the Western Brazilian Company, according to an existing agreement. The purchase of the Western and Brazilian lines is provided for. If the purchase were carried out the agreement would cease, and the Brazilian Submarine Company would be free to go on with a cable. At the present time they have no power. Looking at the agreement, the purchase by the Government was an improbable eventuality, and this, no doubt, has entered into the calculations of the Brazilian Submarine Company. Need there, therefore, be any surprise? He thought they could rely on the impartiality of the Brazilian Government. The Brazilian Submarine Company could, no doubt, uphold its own, but they appeared to think that the Western Brazilian Company had behaved in an unfriendly way in Brazil. As a matter of fact, they had always endeavoured to maintain friendly feeling with this company. Their interests were so identical, that a departure from such a policy would be fatuous. He thought that whether the Western lines be purchased or not, provided they did their best to earn the approval of the Brazilian Government, they would be treated accordingly. Negotiations were going on with regard to the sale of a ship, and they would be able to strike one of these off their lists.

He then moved the adoption of the report, which was seconded and carried.

The British Electric Traction (Pioneer) Company, Limited.

This company has been formed with a share capital of £100,000, divided into 10,000 shares of £10 each, to take steps for the development of electric traction in the United Kingdom and elsewhere on systems which have already proved successful in the United States and on the Continent of Europe. The company will also investigate and test new and improved systems, and in due course will form a larger company with adequate capital.

That tramways can be more economically and efficiently worked by electricity than by horse or steam power is the view of leading engineers and of the technical Press both in this country and abroad, and is also borne out by practical experience in America and elsewhere.

In Mr. Dawson's article in *Lightning*, September 26th, 1895, the following data are given, which illustrate the enormous growth of electric tramways in America during the past five years, as compared with other systems of traction:—

	1890. Mileage.	1894. Mileage.
Electric	2,523	9,008
Horse	5,400	2,243
Cable	510	662
Steam	604	614

These figures show that while 3,157 miles, or 58 per cent. of horse tramways existing in 1890 have been abandoned, those worked by electricity have increased by 6,485 miles, or 250 per cent.

The experience obtained in the United States and on the Continent proves that the substitution of electricity for steam or horse-power leads to considerable augmentation in the earnings of tramway companies by reducing the working expenses and increasing the number of passengers.

The company is not committed to the use of any particular system, but will aim at developing electric traction on the most approved methods, and according to the requirements of each locality. Some important inventions and proposals relating to electric traction have been submitted to the directors, and will receive early attention. The profits of this pioneer company will depend upon the successful issue of the capital of the larger company.

The only contract entered into is made between the pioneer company and the Electric and General Investment Company, dated November 12th, 1895, whereby the benefit of certain preliminary investigations into electric traction have been secured, and the Investment Company agrees to pay all expenses of the Pioneer Company up to allotment, and to give its assistance in the launching of the proposed larger company upon the terms set out in the contract.

Copies of the memorandum and articles of association, and of the above-mentioned contract, can be seen at the offices of the Electric and General Investment Company, and of this company, and applications for shares must be made on the accompanying form, and forwarded to the bankers with the amount of deposit. If no allotment is made, the deposit will be returned; and where the number of shares allotted is less than the number applied for, the available balance will be applied towards the payment due on allotment, and any excess returned to the applicant.

Prospectuses and forms of application can be obtained from the bankers, the brokers, the Electric and General Investment Company, Limited, and at the offices of the company.

The Electric and General Investment Company, Limited, Nos. 1 and 2, Great Winchester Street, E.C., invite subscriptions for the present issue of 5,000 shares of £10 each, payable: £1 per share on application, £1 per share on allotment. Calls not exceeding £2 per share will be made as necessary at intervals of not less than one month.

The board of directors consists of Sir Chas. Rivers Wilson, G.C.M.G., C.B., Chairman; the Right Hon. the Earl of Suffolk and Berkshire, director of the City of London Electric Lighting Company, Limited; J. S. Raworth, M.Inst.C.E., chief engineer, and joint manager of the Brush Electrical Engineering Company, Limited; Emile Garcke, M.Inst.E.E., managing director of the Electric and General Investment Company, Limited, managing director.

Electro-Chemical Company, Limited.

The second ordinary general meeting of this company was held at St. Helen's on 5th inst. Col. T. J. Holland, C.B., presiding.

The Chairman placed before the shareholders an account of the arrangements made for manufacturing operations, contracts entered into for electrolytic and electrical generating plant. They had now got to work, and were daily demonstrating to the chemical and electrical professions that purer and better bleach and caustic soda could be made by their electrolytic process than by any of the older processes and at 50 per cent. less cost. He also referred to the foreign and colonial patents and various other matters of interest. We shall print a full report in our next issue.

Stock Exchange Notices.—Application has been made to the Stock Exchange Committee to allow the following to be quoted in the Official List:—Chelsea Electricity Supply Company, Limited, 6,000 6 per cent. preference shares, Nos. 14,001 to 20,000, and a further issue of 3,723 ordinary shares.

Victoria Electric Railway and Lighting Company, Limited.—The numbers are published of the 5 per cent. first mortgage debenture bonds, amounting to £1,000, which have been drawn for repayment on and after January 2nd, at the rate of £105 per cent.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending November 10th, 1895, amounted to £1,009; week ending November 11th, 1894, £969; increase, £40; total receipts for half-year, 1895, £16,658; corresponding period, 1894, £16,719; decrease, £61.

The Liverpool Overhead Railway Company. The receipts of this railway for the week ending November 10th, 1895, amounted to £1,063; corresponding week last year, £892; increase, £171.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending November 8th, 1895, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,9

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation Nov. 6th.	Closing Quotation, Nov. 13th.	Business done during week ended Nov. 13th, 1895. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	...	4 %	4 %	102 —105	102 —105	...	...
1,912,880£	Anglo-American Teleg., Ltd.	Stock	£2 15s.	£2 11s.	£2 2s.	43 — 45	43 — 45	43	...
2,993,560£	Do. do. 6 % Pref.	Stock	£5 10s.	£5 2s.	£4 4s.	83½— 84½	82½— 83½	84¼	82¾
2,993,560£	Do. do. Defd.	Stock	...	...	...	6½— 6¾	6½— 6¾	6⅝	6½
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% §	6½% §	...	13¾— 14¼	13¼— 13¾	13½	13 5/16
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	...	111 —115	111 —115	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	10%‖ §	... §	2½%	3½— 4	3¼ — 3⅜	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	164 — 168	164 —168	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	2 % §	1½%	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	13 — 14	13 — 14	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20½— 21½	20½— 21½	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	4 — 5 xd	4 — 5	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	...	4½%	104 —107	104 —107	...	...
60,710	Direct United States Cable, Ltd.	20	3½% §§	2⅝% §§	2 %	8 — 8½	8¼— 8⅜	8⅜	8¼
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §§	6½% §§	6½%	16¾— 17	16½— 17	16⅝	16¼
70,000	Do. 6 % Cum. Pref.	10	6 % §§	6 % §§	6 %	17¾— 18¼	17⅝— 18¼	...	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	5 %	107 —110	107 —110	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	4 %	126 —129	126 —129	...	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	17¾— 18¼	17½— 18	18⅛	17 9/16
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	103 —107	103 —107	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	104 —107	104 —107	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	128 —131	127 —130	...	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	103 —107	103 —107	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	104 —107	104 —107	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	108 —111	108 —111	109½	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	112 —115%	112 —115	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅞% §§	4⅝% §§	4½%	9¾— 10½	9½— 10	10⅛	9⅝
180,042	Do. do. 6 % Pref.	10	6 % §§	6 % §§	6 %	16¾— 17¼	16 — 17	16 3/16	16½
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅝% §§	8⅝% §	8⅝%	21¼— 22¼	21⅜— 22¼	...	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	47 — 50 xd	47 — 50	48	...
100,000£	London Platino-Brazilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	106 —110	106 —110	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	...	...	...	2 — 2½	2 — 2⅛	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 % §	5 % §	5 %	6 — 6¼	5⅞— 6⅛	6¼	5⅞
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	16 — 18	16 — 18	17	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	15½— 16½	15½— 16½	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6¼— 6½	6¼— 6⅜	6 7/8	6¼
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	105 —107	105 —107	106½	106¼
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	4¼%	2/16— 3/16	2/16— 3/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	109 —112	109 —112	...	...
11,839	Reuter's Ltd.	8	5 %	0 %	*nil*	5½— 6½	5½— 6¼xd	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	127 —132	127 —132	129½	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	2¾— 3¼	2¾— 3¼	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	92 — 97	92 — 97	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	...	...	*nil*	5½— 6½	5½— 6½	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107	104	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1½— 2	1 — 2	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	100 —105	100 —105	...	...
64,248	Western and Brazilian Teleg., Ltd.	15	2½%	2½%	3 %	10 — 10½	9¾— 10¼	10⅛	9¾
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	6½— 7	6½— 7	6 1/16	...
33,129	Do. do. do. Def. Ord.... ...	7½	...	...	1 %	3½— 4	3¼— 3⅜	...	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	103 —107	103 —107	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	6 %	103 —107	103 —107	104	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	¼%	¼%	7/8— 1⅛	¾— 1⅛	...	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	10½— 10⅝	10½— 10⅝	10⅝	10 7/16
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	8½— 9½	8½— 9⅛	9⅜	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	111 —114	111 —114	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	110 —115 xd	110 —115	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	100 —103	100 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	5 %	4½%	4½%	5¼— 5⅜	5¼— 5⅜	5⅜	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	...	...	...	6¾— 7¼	6¾— 7¼	...	...
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	...	116—119	116 — 119	116	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	5 %	12½— 13½	12¼— 13½	...	...
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	15½— 16½	16 — 16½	16½	15¾
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	132 —136	131 —135	135	132¼
22,475	County of London and Brush Prov. Elec. Ligtg., Ltd., Ord. 1—22,475	10	...	...	...	8½— 9½	8½— 9½	...	...
10,000	Do. do. do. 6% Pref., £6 pd., 40,001—50,000	10	...	...	...	8¾— 9¼	8¾— 9¼	...	...
50,000	†Liverpool Electric Supply, all paid	5	5 %	5 %	5½%	7⅞— 8½	7⅞— 8½	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2 %	2½%	3 %	10½— 11½	10 — 11	10 15/16	10¾
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	117 —120	117 —120	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	1 %	8½— 9½	8¼— 9½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	7½%	4½%	6½%	8¼— 8⅝	8 — 8½	8⅝	8 5/16
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9 — 10	9 — 10	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	3½%	4 %	5 %	8¼— 8⅜	8 — 8½	8⅜	8

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

Unless otherwise stated all shares are fully paid. ‡ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked ‖ are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, Nov. 6th.	Closing Quotation, Nov. 13th.	Business done during week ended Nov. 13th, 1895. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	6 % §	6 % §	...	1⅜ — 1⅝	1½ — 1⅝	1½	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §	6 % §	...	2 — 2¼	1⅞ — 2⅛	2	1⅞
125,000*l*	Do. do. 4½ % Perp. Deb. Stock.	Stock	4½%	4½%	...	112 —115	112 —115	113½	...
630,000*l*	City and South London Railway	Stock	⅝%	⅝%	1¼%	40 — 42	40 — 42	40¼	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	...	1½ — 2½	1½ — 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	...	...	5 %	1⅔ — 2¼	1⅔ — 2¼	...	...
17,139	Do. do. do. "A" Shares 01—017,139	5	...	...	...	2⅔ — 3¼	2⅔ — 3¼	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	..	...	4½%	104 —107	104 —107	106	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	*nil*	¾ — 1	¾ — 1	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	7 %	2 — 2½	2 — 2½xd	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	⅝ — ¾	⅝ — ⅝	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	⅞ — 1⅛	⅝ — 1	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	...	¼ — ⅜	¼ — ⅜	...	...
9,600*l*	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	*nil*	...	6½ — 7½	6½ — 7½	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	6 %	14 — 14½	14 — 14½	14¼	...
3,000	Do. do. do. 7% Pref.	10	...	...	...	15½ — 16½	15½ — 16½xd	16½	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	...	...	107 —110	108 —111	110	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	10 %	19 — 20	19 — 20	19¾	19
200,000*l*	Do. do. do. 4½ % Deb., 1896	100	4½%	4½%	4½%	101 —103	101 —103	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	1 %	1½%	11⅞ — 12	11⅞ — 11⅞	...	...
10,000	† Do. do. Pref., £10 paid	10	...	5 %	5 %	15½ — 15⅝	15½ — 15⅝	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	15 %	20 %	20 %	42 — 44	40 — 42	43	41½
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
54,000*l*	Waterloo and City Railway, Nos. 1 to 54,000, £4 paid ...	10	...	...	...	4⅛ — 4⅞	4⅜ — 5	4 1/16	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 189

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

CROMPTON & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅜—6¼.

Electric Construction Corporation, 6 % Debentures, 98—103.

House-to-House Company (£5 paid), 4¼—4⅜.

Do. do. 7 % Preference, of £5, 7⅜—8¼.

Do. do. 4½% Debentures of £100, 110—112.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 7⅜—8¼; 1st Preference Cumulative 6 %, £5 (fully paid), 5⅜—6¼.

Liverpool Electric Supply, £5 (fully paid), 7⅜—8¼.

London Electric Supply Corporation, £5 Ordinary, ⅜—⅝.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 6½—7.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

THE ARC LIGHT.*

BY PROF. SILVANUS P. THOMPSON, D.Sc., F.R.S.

Lecture I.—Delivered January 14th, 1895.

(*Continued from page 575.*)

Now, let us try to sum up what is known on this point. Carbon, the most refractory of known substances, has a definite temperature of volatilisation when the pressure is kept constant. Change of pressure will change that temperature. However intense the heating effect of the current, however fiercely we pour in energy by means of the electric circuit, we cannot raise the free surface where the carbon is evaporating above that limiting temperature. Increasing the rate at which heat is poured in will simply increase the rate of evaporation. Further, carbon is found at these elevated temperatures to have chemical properties of the most active kind. No known compound exists that is not dissociated at arc temperatures. Put any of the most refractory substances known—lime, magnesia, alumina, asbestos—into the arc, they are dissipated, reduced, volatilised; mix any of them with the carbon, and one finds that, *without exception*, the effect of their presence is to reduce the temperature, to lower the degree of luminosity, and—what is most significant—to lower the apparent back electromotive force. Increase of pressure, however, raises the temperature and raises the luminosity. What a glimpse this gives us of the possible state of things going on at the surface of the sun. For some reason—into which I need not enter—the temperature at the sun's surface is very high, higher, to judge by the radiation, than that of the crater of the arc. Also, the pressure of the solar atmosphere, at the level of the sun's surface, must be much higher than the one atmosphere of our air. At such temperatures (and pressures) all known chemical compounds would be dissociated into their elements, and all the known elements would be volatilised. The last element to be volatilised would be carbon. Are we not justified, then, in hazarding the suggestion that the luminous surface of the sun, to which it owes its brightness, is in reality a surface of incandescent carbon? If not, what else can it be?

[*Remarks since added, October*, 1895.—It is only just to add, in view of later researches, that there is some evidence not concordant with the views put forth in this lecture in January. Experiments made in Ireland by Mr. W. E. Wilson* go to show that under certain conditions the light given out by an arc lamp is reduced in brilliancy when the lamp is burned under a pressure of several atmospheres. Mr. Wilson considers that he has shown that the intrinsic luminosity is lowered. If this should be established, it will of course mean that the temperature also is lowered by pressure, and that, therefore, the temperature of the arc cannot be considered as dependent upon the temperature of volatilisation of carbon. But it remains to be proved whether the temperature of volatilisation of carbon is so lowered by pressure. The matter is complicated by the circumstance alluded to in the lecture, that the melting point of carbon is so close to its boiling point. In the absence of any knowledge as to whether at the fusion point any change of volume occurs, and whether such change be an expansion or a contraction, it is impossible to say whether increase of temperature will raise or lower the melting point. All one can say is, that the question raised is still in suspense, and that for the present Mr. Wilson's observations are distinctly against the theory put forward.

Further, in September, 1895, at the meeting of the British Association, Prof. Ayrton and Mr. Mather communicated a paper on the apparent back electromotive force of the arc, which they had been examining by a new method of electrical measurement. This method cannot be discussed here, but there are grave doubts as to its validity. Using this method, the extraordinary result was obtained that the supposed back electromotive force is a negative quantity, that is to say, instead of an electromotive force opposing the current, they found a forward electromotive force helping it. If this were true, it would involve the admission that the arc would be acting as a source of electric power, and it would also involve the admission that the resistance of the column of vapour of the arc is greater than can be accounted for by the fall of potential per unit of length, both of which conclusions would be inadmissible.—S.P.T.]

* Cantor Lectures. From the *Journal of the Society of Arts*. References to this series of Cantor lectures will be found in the ELECTRICAL REVIEW for January 18th and 25th, and February 1st, 1895.

* "*Proc.* Roy. Soc., May 30th, 1895, or see the *Electrician*, June 21st, 1895, p. 261.

Researches of Prof. Ayrton.

Any account of the physics of the arc would be incomplete which did not include a reference to the researches of Prof. Ayrton. I listened, when at the Electrical Congress at Chicago in 1893, with the utmost delight to a very elaborate paper, which cleared up a number of doubtful points, and gave us far more complete details about the phenomena of the arc than anything hitherto available. Observations had been made by Prof. Ayrton, and by Mrs. Ayrton, of the same sort as those which I and other observers had made in time past. They had been carefully comparing the length of the arc, the voltage, the current, size of crater, and so forth, but over very much larger ranges, and with more perfect appliances than any previous observer. In particular, they had found that if after adjusting any of the conditions as to length, current, and the like, a sufficiently long time (exceeding half an hour, if I remember aright) were allowed to elapse, the crater and peak settled down to a special form corresponding to those conditions. And that to every change of length or of current there corresponded a different form. Only when each separate experiment—and there were hundreds of them—had been carried on for a sufficient length of time, could readings of voltage be obtained which were truly normal. Results obtained in this patient way, when plotted out in curves, showed the most surprising regularity. Instead of the broken curves (such as Frölich's,) of the earlier observers, curves of smooth outline were obtained. Also the observations had been pushed further. The curves had been carried to extremes—for very large currents, and very small currents; to very high voltages and very low voltages; with very short arcs and very long arcs; with very big craters and little craters. Those curves contained by far the most complete account of the natural history of the arc than anything yet published. I looked forward to the publication of these results with great interest. Sad to relate, the scientific man to whom Prof. Ayrton entrusted the papers before he left America to return home, after keeping them beside him for some months without sending them to press, allowed his negro servant to use them for lighting fires. Only a few fragmentary notes remain. I have urged Prof. Ayrton to renew his labours, and repeat investigations of such importance, and I am glad to say that we are likely to have something soon from him to repair the loss. But until that appears I shall feel, at any rate, as though a very large part of the physics of the arc was still wanting.

[*Note added, October*, 1895.—During the course of the current year, Mrs. Ayrton has communicated to the *Electrician* a series of papers embodying the fragments of the research of which the records were so shamefully treated, together with the results of renewed experiments. Mrs. Ayrton has further communicated to the British Association, in September, 1895, a paper on the formulæ for expressing the relation between voltage, current, and length of arc. The results of these observations are so important, that it would be an injustice to their merits to attempt to summarise them here. Mrs. Ayrton's formula has been added to those exhibited in the Table on page 949 of *Society of Arts Journal*.—S.P.T.]

Arc Furnaces.

From the time of De la Rive and of Despretz, experiments have been made on the use of the arc for electro-metallurgical processes, owing to its very high temperature, and the reducing action of carbon. Napier, in 1845,* presented to the Society of Arts an electric furnace intended for the reduction of metals, consisting of a lined plumbago crucible, into which a carbon electrode was introduced. Sir W. Siemens was amongst the first to revive the construction (fig. 9) of an arc furnace. He introduced, through the

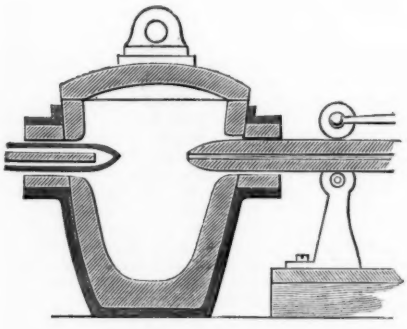


Fig. 9.

sides of a crucible, refractory and non-conducting material, two pencils of carbon, between which the arc was formed. Since then great progress has been made by Cowles in the production of aluminium alloys, and by Moissan and others in the reduction of metals. A wide field for commercial development has thereby been opened.

Another thing has to be done; the chemists must go to work. The chemistry of carbon at high temperatures is one of those things that ought really, now that the supply of electricity is so common, to be easy to experiment upon. The electrician provides what the chemist wants, the means of making a high temperature with an arc. What the chemist has not yet worked out is the chemistry of carbon at high temperatures. Thus, we know that chemists have not found a compound yet that cannot be decomposed into its elements at the temperature of the arc in the presence of carbon, so that carbon appears to be the nearest approach yet to the universal solvent. When I deal next week with the optics of the arc, I shall recur to this matter of the behaviour of carbon itself; but from this point onwards—that is to say, in my next lecture and in the one afterwards—I do not propose to return to any of the other materials that have been proposed. It simply is waste of time at present to deal with arcs made with any other material than carbon; in fact, I will take this one of the 70 known elements, and confine myself to it. And I will deal with that element in a particular way, viz., as used in the making of an arc at about 40 to 50 volts, leaving aside all high voltage phenomena, all vacuum phenomena, all the abnormal phenomena of the arc, confining myself to the arc as we know it for industrial purposes.

Lecture II.—Delivered January 21st, 1895.

OPTICS OF THE ARC.

The optical phenomena of the arc are nearly as complicated as are those electrical phenomena which occupied us a week ago. They vary with every different kind of carbon that one may employ, with every different value of current that one may use with a given carbon, and with every different kind of adjustment that one may have in the lamp that regulates the carbon. In a lecture such as this, one can only deal with a few salient facts in a few typical cases.

Distribution of Light of the Arc.

The first and most important case to consider is that of the normal arc produced by the continuous current. There are two possible general cases of this also. The first case is that in which the current descends from the upper carbon to the lower, and is generally adopted for the lamps used for outdoor work. The second case, which is rather exceptional, and is only adopted in certain cases of indoor illumination, is that of the inverted arc, where the current ascends from the lower carbon to the upper. As the former is the more usual, we will deal with it. In this lantern we have now an arc formed; the particular regulator employed here being a Serrin lamp of the old fashioned sort. I use it rather than any more modern mechanism, simply because it is convenient as a table lamp. In front of the arc, which is formed here between these carbons, we have a lens in order to project the view of the arc upon the screen, and we can, if need be, introduce in front of the lens an erecting prism to rectify the position of the image on the screen. You now see upon the screen the image of the arc formed between the carbons. The positive carbon, with its luminous crater, is at the top; the negative, with its

Fig. 10.

characteristic peak, is at the bottom; and in between them is a violet coloured flame or arc, consisting of the column of carbon vapour through which the current descends. By a very small adjustment of the upper carbon, I arrange the position of the points so as to enable you to get a better view of the crater. Here is the first and most obvious optical fact, that the light comes from the white hot surface from which the carbon is evaporating. About 90 per cent of the light comes from the crater, and about 4 or 5 per cent. from the negative peak, while comparatively little light comes from any other part. Around the rim of the crater there is, however, a region that is less luminous, not so hot, and of a redder colour; and there is a certain small percentage of light—not more than 3 or 4 per cent. of the total light, at most—emitted from the intermediate flame. Now, of course, there results from this a peculiar distribution of light in the space all round; the light is, in fact, thrown mainly downwards.

When it is desired to throw the light not symmetrically downwards, but to project more of it in a horizontal direction, we resort to the device, introduced first by Duboscq, of displacing the line of the carbons, so that the negative peak instead of being exactly under the centre of the upper carbon, is brought a little forward (as in fig. 10). The crater then forms obliquely, with the negative peak in front of it. This effect I will now produce by simply shifting the upper carbon backwards. As I gradually displace the upper carbon to one side, the form of the crater will change; the positive carbon will burn away more on one side than the other. It takes a few minutes to change its shape, during which time the light will be unsteady; and when the new form has been assumed, we shall find that the light is thrown mainly on one side, as is desired for projector purposes, and for use in the optical lantern. We may have to let the arc burn untouched for something like half an hour, in order that the

* See *Mechanics' Magazine*, 1845, p. 432.

final shape of the surfaces may be properly assumed. As the maximum emission of the light is at right angles from the luminous surface, we shall now have obviously a different distribution in the illumination.

Distribution Curves.

For a period of 15 years or more back, it has been customary in the laboratory to measure and plot out the amount of light given by arcs in different directions, and to study the curves of distribution produced in that way, Two examples of these are shown in fig. 11. Curve, A, relates to an arc produced at a constant voltage on a low-

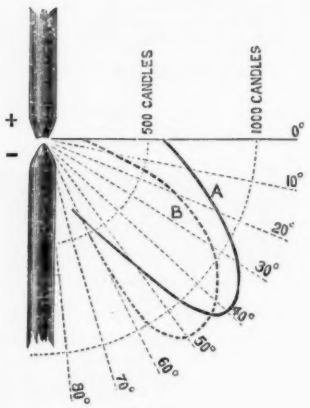


Fig. 11.

pressure system of supply. Curve, B, to an arc produced with an unvarying current on a high-pressure system of supply; other arcs being in series with the one measured. The mean current for both was about the same. The data of the measurements (which are taken from an American source) are given in the table below.

(A) Low-pressure.		(B) High-pressure.	
Angle.	Candle-power.	Angle.	Candle-power.
0°	593·7	0°	210·5
10°	719·1	10°	407·4
20°	866·3	20°	687·4
30°	1,094·0	30°	977·1
40°	1,183·0	40°	1,079·0
50°	682·2	50°	1,140 0
60°	495·4	60°	595·7

If we select some photometric arrangement which will enable us to measure the amounts of light given out in different directions horizontally, and at different angles downwards, we can then plot out

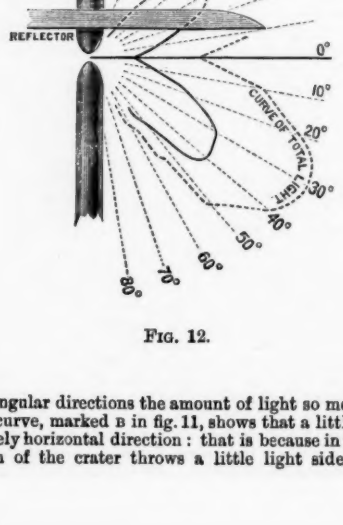


Fig. 12.

along these angular directions the amount of light so measured. The distribution-curve, marked B in fig. 11, shows that a little is given out in an absolutely horizontal direction: that is because in that direction the lower rim of the crater throws a little light sideways. At an angle of 10° downwards there is a little more light, and at 20°, 30°, 40°, 50°, one finds that there is an increasing amount until you come to the maximum in one particular direction, which, in this case, is about 50° from the horizontal. As you go further along you find that the light suddenly diminishes, not absolutely abruptly, but very rapidly, while absolutely straight down there is no light thrown at all. Obviously, in that case, there is no light because the bottom carbon and its holder throw a shadow. The curve, A, in fig. 11, is another plot taken from a different lamp, under different circumstances. Let us now compare the curves so plotted with fig. 12, which shows a plot relating to an alternating current lamp. In such lamps the two tips do not materially differ in form from one another, provided the quality of carbon is alike, and the pencils of equal thickness. Both tips take the form of a blunt peak. This form would be exactly alike were it not for the fact that the hot air ascending at the sides heats the upper carbon more, so that it becomes slightly more coned than the lower one. In this case the black curve represents the amount of light in various directions. Some is thrown downwards at an angle, and almost an equal amount is thrown upwards at an equal angle, with intermediate values in intermediate directions. But if a reflector is interposed to catch the light that is going upwards and throw it also downwards, one obtains the distribution plotted out in the dotted curve.

Dependence of Distribution on Shape of Crater and Peak.

During the minutes which have elapsed, our arc has been steadily burning, and the crater on the upper carbon has assumed the oblique position. The peak remains as a peak, and is visible against the crater surface which it partially hides from our view. The main amount of light (see fig. 10) is now given off in a not quite horizontal direction.

To make experiments on the amount of light given out in different directions, one requires either a photometer capable of being shifted round into all possible angular positions, or some apparatus for turning the arc into different inclinations with respect to the photometer. There is, however, an intermediate possibility, namely, some method of optically tilting the lamp so that its light shall still come to the photometer, no matter what the inclination may be. To enable you to see upon the screen what the arc looks like when viewed at different inclinations, the following apparatus has been devised (fig. 13).

Here is a small projector lamp (made by the Planet Company) for the purpose of magic lantern work. This little lamp is fixed on a cradle-shaped stand, so that it can be rocked about on horizontal trunnions; the line of axis of these trunnions passing right through the arc. When the arc is burning steadily, while we project its image upon the screen by means of a lens placed in front, we can tilt it to any angle desired, and set it either vertically, or with any desired inclination towards the horizontal plane. So here we accomplish the same result as viewing the arc obliquely from positions below.

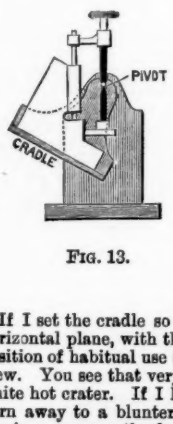


Fig. 13.

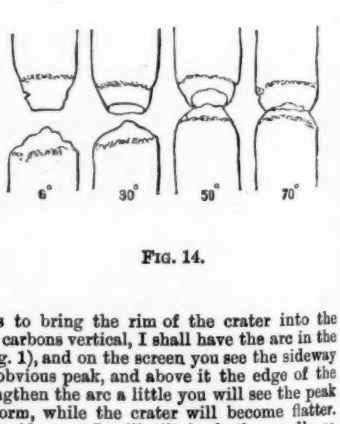


Fig. 14.

If I set the cradle so as to bring the rim of the crater into the horizontal plane, with the carbons vertical, I shall have the arc in the position of habitual use (fig. 1), and on the screen you see the sideway view. You see that very obvious peak, and above it the edge of the white hot crater. If I lengthen the arc a little you will see the peak burn away to a blunter form, while the crater will become flatter. Having now seen the form sideways, I will tilt back the cradle, so that we may get another view of it. The duller spot which you see in the middle of the crater arises from the circumstance that we are employing a cored carbon, that is to say, a carbon with a hole down the middle, packed with carbon of a more or less soft quality, and possibly not quite pure. As the cradle is tilted the negative peak comes in front of the crater, and shows dark against its luminous surface. Turning it to a still steeper angle, so as to get in a horizontal direction the equivalent of the light which would otherwise be thrown obliquely downards, we find the negative peak almost eclipsing the crater, and cutting off its light.

Fig. 14 shows four views at four different angles, 0°, 30°, 50° and 70°. In the two extreme positions, where the crater is seen only edgeways, and where it is eclipsed by the peak, there is very little light; but at some angle between these two there will obviously be a position where the light is a maximum. The crater, at first seen edgeways, seems to open out into an ellipse, which widens, until the intruding peak eclipses it. There will obviously be a maximum position between the two minima. For a long time this was not very well explained. M. Rousseau, who made some observations by means of a polar photometer, on the arc lamps shown at the Exhibition at Antwerp, in 1885, tried to express the results by using some long and complicated formulæ.

(To be continued.)

THE INSTITUTION OF JUNIOR ENGINEERS PRESIDENTIAL ADDRESS.*

By ARCHIBALD DENNY, Esq., M.I.N.A.

(*Concluded from page* 570.)

The next step in the ladder is when you become a principal or partner in a business, and now your burden is greatly increased. You no longer work, in all likelihood, for a salary, and you have therefore all the care and anxiety of making sure of your livelihood. But you have a high duty also to all those under you, and you should take an interest in them not only in the works, but outside of the works; not a patronising interest, not a mere subscribing to their schemes, their football clubs, cricket clubs, &c, but take an active interest in their pleasures and in their sorrows, and in doing so, you will not only lighten their cares, but you will also have your own cares lightened by their sympathy and human interest. Above all, avoid trying ill-considered socialistic experiments, which to be successful, assume that working men are all angels; they are no more angels than you are, and such schemes are failures before they are tried; only benefit schemes on a sound financial and co-operative principle will succeed; I mean those which are just to both parties.

I may mention two schemes which have proved successful in my own experience, viz., an accident fund, managed by a committee, appointed in equal numbers by both master and men, and to the funds of which equal contributions are made; and also an awards scheme, by which men are rewarded, who either invent new methods or machines, or introduce any scheme by which production is cheapened.

Should you unfortunately after all your efforts be confronted by a prospective strike, consider well the situation, make up your mind what under the worst circumstances you would be induced to accede to, and having done so, say a final yea or nay. Do not be readily induced to begin a strike and then give in; vacillation of this kind has been the leading cause of strikes. If the men realise that when you say yes you mean yes, and no, no, strikes will not readily occur, and you will notice that the modern tactics are all tending towards avoiding strikes if at all possible. The men always lose by them, and also the masters, for even if success crown the efforts of either party, the gain is never sufficient to make up for the individual loss.

I happened to read recently a paper by an American—Mr. Fred. W. Taylor—read before the American Society of Mechanical Engineers. In his paper there are a few sentences which so thoroughly express my own views, that I am sure Mr. Taylor will not object to my extracting them for you. He says, "No system of management, however good, should be applied in a wooden way. The proper personal relations should always be maintained between the employers and men, and even the prejudices of the workmen should be considered in dealing with them. The employer who goes through his works with kid gloves on, and is never known to dirty his hands or clothes, and who either talks to his men in a condescending or patronising way, or else not at all, has no chance whatever of ascertaining their real thoughts or feelings."

"Above all, it is desirable that men should be talked to on their own level by those who are over them. Each man should be encouraged to discuss any trouble which he may have, either in the works or outside, with those over him. Men would far rather even be blamed by their bosses, especially if the 'tearing out' has a touch of human nature and feeling in it, than to be passed day by day without a word, and with no more notice than if they were part of the machinery."

"The opportunity which each man should have of airing his mind freely, and having it out with his employers is a safety valve; and if the superintendents are reasonable men, and listen to and treat with respect what their men have to say, there is absolutely no reason for labour unions and strikes."

"It is not the large charities (however generous they may be) that are needed or appreciated by workmen, such as the founding of libraries and starting working men's clubs, so much as small acts of personal kindness and sympathy, which establish a bond of friendly feeling between them and their employers."

These sentiments have been the ruling factor in my firm since we began business, now 50 years ago, and when I tell you that no strike has occurred in our works since the year 1877, you may take it as a proof that our system of management, working on these lines, has not been unsuccessful.

To be a successful business man requires a combination of qualities. It requires at the very beginning, a certain knowledge of business methods and means, and none perhaps is so important as to understand the system of costing, and cost-keeping. This is too large a subject for me to enter into fully; there is only one point which is of such primary importance that I wish to deal with it in some detail. I refer to the question of charges—standing charges, as they are sometimes called.

These charges vary in various businesses, and in various localities; roughly, they may be classified under the following heads:—

(1) Conveyance; (2) coals; (3) stationery and printing; (4) gas and lighting; (5) repairs on buildings; (6) repairs on plant; (7) general upkeep and repairs; (8) naphtha, waste, oil, &c.; (9) stamps and telegrams; (10) water; (11) taxes and rent; (12) fire and boiler insurances; (13) salaries administrative; (14) salaries technical; (15) salaries commercial; (16) travelling expenses; (17) upkeep of contracts; (18) cleaning offices and sundry; (19) extra charges; (20) legal expenses; (21) depreciation.

Different men consider different items as fixed charges, but the list I have given you is not an uncommon one.

The following explanatory remarks may be useful:—

1. Conveyance. This is for carriage of material to and from the works. Of course, most supplies are bought carriage paid; some cannot be treated in this way, and in despatching goods the expenses must be met.

2. Coal. This is one of the items which bulks largely in most businesses, and should be carefully watched. The quality of coals is one of the principal items, and carelessness on this head will soon run up a heavy bill. In a large business you will find it pay to have one man devote a large proportion of his time to watching this item alone.

3. Stationery and printing is an item apt to grow, and one in which the staff, more than the principal, can exercise economy.

4. Gas. You will find it useful to read your meter, or meters, every week; large leaks are likely to occur, which can only be checked in this way.

5 and 6. Repairs on building and repairs on plant are largely dependent upon the skill and care of the manager.

7. General upkeep and repairs. These items, which belong to neither of the other two, consist in small jobbing accounts, which can grow if not watched.

8. Naphtha, waste, oil, &c. It is better to have these a separate item in charges, rather than to attempt dividing them over each job.

9. Stamps and telegrams. The telegram bill must be watched.

10. Water. The same remark applies to this as to gas.

11. Taxes and rent are largely uncontrollable.

12. Fire and boiler insurances. Too much economy in this may lead to disaster in the event of an accident.

13. Salaries administrative; that is, those paid to manager, under managers, &c.

14. Technical salaries; those paid to drawing office staff.

15. Commercial; those paid to the counting house staff. I shall deal with these two latter items more fully immediately.

16. Travelling expenses; the travelling expenses of the staff when for any definite job should be carried directly to that job; these carried to charges should be those only of the principal and manager, which are very often incurred in looking for work which is not secured, or general travelling.

17. Upkeep of contracts; there is a good deal of chance and luck affecting this item. Of course, careful work in the first instance reduces it to a minimum, but it is frequently advisable in large risks to cover by insurance.

18. Cleaning of offices, &c., explains itself.

19. Extra charges, viz., those items which cannot be charged to any more definite account, such as special bonuses to employees or outsiders.

20. Legal expenses; I can only express the hope that this may be a small item, and advise you to avoid law even at the sacrifice of what you may consider strict justice in some cases. It is an old saying that the only man more to be pitied than the loser in a law case is the winner.

21. Depreciation; this is a most serious item, and one which cannot well be too large. If the partners in a business are of greatly different ages, it is to the advantage of the younger member, and to the disadvantage of the older, that this item should be large. The legal depreciation allowed by the income-tax authorities is too small. Good practice is to take 10 per cent. off the original cost of all tools year by year until they are virtually written down to scrap price. If your business is to succeed, you must be continually adding new machines, and as it is not advisable to go on increasing your capital indefinitely, therefore your power of purchasing new machines must be largely derived from the depreciation of those you already have.

If your buildings are substantial, 2½ per cent. may be enough, provided that in both cases you upkeep your buildings and tools from revenue.

Depreciation should be the first consideration, and division of profits should only come in after the depreciation account has been fully satisfied.

In most businesses it is usual to find out, by years of experience, what roughly is the percentage these charges bear from year to year to the wages bill. The wages bill is chosen because it is less fluctuating than materials, and because it is some measure of your power of output, I mean how much work you can turn out. I will not go into detail for many reasons but roughly, and as a guide to you, if you are ever called upon to decide this question, in shipbuilding, if you find these charges exceeding 30 per cent., it is time to carefully consider the position of affairs, and if you find them falling below 20 per cent., it is also time to look carefully into matters, and for this reason. One of the largest items under charges is salaries of draughtsmen, clerks, managers, &c. Now, you can either have this item too large or too small. If it is too small, there will be insufficient supervision or insufficient plans; this will increase the total expense of working, the wages will rise, and apparently your charges will fall in percentage. On the other hand, it is quite clear, if the staff is too large, this leads directly to large charges, with probably a moderate wage bill. Staff should, therefore, be only pushed to such a point that the wages are kept a minimum by careful supervision; beyond this, increase of staff is a questionable advantage. I am not so cognisant of what charges should be in a marine engine works, but from what I can learn, you would require to study the position of affairs should they exceed 30 per cent. of the wages. I do not lay these down as fixed limits; charges largely depend upon the size of the business, the amount of turn over, and I have been considering medium sized concerns, but they will be some guide to you starting with probably little experience.

My final advice to you is to make your work your first business, but do not allow it to entirely absorb your attention; you should have some harmless hobby or amusement to which you can turn

* Delivered November 1st, 1895, at Westminster Palace Hotel, London.

your attention when the day's business is done; you should not always carry your business on your shoulder like the "old man of the sea."

In business, be careful of the small things; they are sometimes more important than the larger issues. While pushing forward with all the energy you possess, be thoughtful for, and careful of others less favoured than yourself; and, finally, while I am not enamoured of Latin, I would like to sum up the matter in two words often used to me by one of my best friends, and excellent advice it is for young men—"Festina lente."

MUNICIPAL TELEPHONY.*

By A. R. BENNETT.

The members of the Northern Society of Electrical Engineers have frequently had before them municipal projects for the supply of electric light and power, and the discussions which have taken place on these subjects have been of great interest and practical utility; but, so far, the society has not taken cognisance of telephones, nor of telephone questions. I have, therefore, chosen telephones as the subject of the paper which I have been invited to contribute, particularly in their relation to municipal authorities.

In this country we have had no actual experience of municipal control of telephone systems, although Glasgow and several of the other Scottish towns are desirous of making a move in that direction; but abroad things have been different, especially in Norway, where in one town of importance the telephone system has been owned and managed for the last six years exclusively by the Town Council; while in Christiania the municipality has contributed to the capital of the local telephone company, and, being represented on its board by three town councillors, exerts a powerful influence on its management. These experiments have been so decisively successful that municipalities in other countries are taking steps to imitate them. Thus we find that the Town Council of Rotterdam is actually engaged in the construction of a telephone system of its own.

The Rotterdam Municipal Exchange is to be opened in October, 1896; it is to be metallic circuit throughout, and the annual subscription is to be £6 5s. 5d. for distances of 5 kilometres, or 3 English miles. The Town Council of Amsterdam has also resolved to build a new exchange, but neither the date of the opening nor the subscription has yet been fixed.

These facts have an important bearing on the present position of telephony in the United Kingdom. Our telephones are now controlled by two bodies only—the Post Office and the National Telephone Company. The exchanges possessed by the Post Office, with the one exception of Newcastle-on-Tyne, where there are some 600 subscribers, are quite insignificant, the Post Office subscribers in the United Kingdom not exceeding some twelve or thirteen hundred in number. The Post Office exchanges, moreover, show no tendency to develop, many of them quite the contrary. Even Newcastle-on-Tyne has remained practically stationary for years, for the Post Office exchange in that town numbered 600 subscribers seven or eight years ago. The result is that the National Telephone Company is virtually invested with a monopoly, which, according to evidence given before the late Select Committee on the telephone service—evidence which is re-echoed from all parts of the United Kingdom—the company does not employ in a manner more calculated to benefit its own shareholders than to satisfy the reasonable requirements of the public.

Independent companies have endeavoured from time to time to compete with the National Telephone Company, but always unsuccessfully, because this powerful corporation has invariably bought up its opponent regardless of cost; tactics which have been rendered successful solely by the support which it receives from the Post Office.

No person or company may construct telephone exchanges in this country without a license from the Post Office, and such licenses have for several years past been withheld. The telephone patents under which the National Telephone Company for many years preserved its monopoly, expired in 1891, and the public then looked forward, as a perusal of the press articles of the period clearly shows, as it had a right to do, to competition as a means of bringing about a reduction of the heavy charges to which it was subjected, and of improving a service which was admitted by the company's own directors to be atrociously bad. But no sooner had the patents expired, and the grasp acquired by the company on the country by their means loosened, than the Post-Office re-invested the company in its monopoly, by refusing to grant any more licenses. The patent laws for 14 years enabled the company to defy all competitors, and when these laws ceased to be operative, the Post Office stepped in and used the power which had been conferred on it by Parliament to confirm and extend the monopoly.

The consequence is that telephonic charges in the United Kingdom are greatly in excess of those which prevail in most other countries, and approximate to double the figure at which they would stand if the earning of a fair dividend on the amount of capital invested in the construction of the exchanges were the accepted principle of the company's action.

Unfortunately, even by the admission of the company itself, its capital consists to a large extent of "water," on which dividends have to be paid; consequently the charges levied on the subscribers must be higher than would be the case if companies or other bodies, unhampered by surplus capital, were permitted to take a share in the supply of British exchange telephones. Before the late Select Committee the National Company admitted that its capital was watered to the extent of £1,292,000. This amount, in the opinion of some who have studied the subject, should be at least doubled; but accepting the company's own figures for the nonce, and likewise the statement that the company's lines numbered 73,338, it appears that £17 11s. of "water" exists for each line owned by the National Company. Well, the late Dundee and District Telephone Company's lines cost £15 each; the late Mutual Telephone Company's (double lines), £16 16s. each; the Christiania Telephone Company's £12 each; the Trondhjem Municipality's £10 2s. 6d. each. It is plain, therefore, on the National Company's own showing, that the "water" which exists for each line erected by the company *exceeds the proper cost of the line*, and that each line must stand in the company's books at much more than twice its actual cost. Such a state of things cannot exist without inflicting grave injury on the telephone subscriber as an individual, and on the commercial interests of the country as a whole, yet it is a state of things that the late Government, through its Postmaster-General, did its best to justify, support, and perpetuate.

Unquestionably, to whatever cause the fact may be ascribed, the development of telephony in the United Kingdom has lagged behind that attained in many other countries. In a paper which I contributed to the British Association at its recent Ipswich meeting, I gave statistics which showed that the United Kingdom, the greatest home of industry in the world, ranked only tenth in the point of telephonic development amongst the European nations, and I sought to account for this unpleasant fact by comparing the conditions which exist here with those which have enabled nine other European countries to outstrip us.

This state of things is a serious one for the British man of commerce. In Germany, Belgium, Norway, Sweden, Denmark, and other countries, we find a large proportion of the towns connected by trunk lines, so that the subscribers may call up their correspondents in all parts of the country. In many cases the trunk lines have now passed the boundaries of the different countries, and the merchants of several of the capitals and of the chief ports and centres of industry in the various States may communicate telephonically. I am, of course, aware that trunk lines exist in this country, and that communication has been established between London and Paris; but there is this important difference. On the Continent the charges made for the use of the trunk lines are extremely reasonable: thus in Germany, one can telephone all over the country for the sum of 1s. per three minutes; and even lower rates prevail in other countries. In the United Kingdom the charges are so heavy (and after January 1st next, when the Post Office will assume control of the trunk lines now worked by the National Telephone Company, they will be still further, in many cases, increased) that trunk line communication remains a luxury. No doubt the Post Office could point to a considerable telephonic traffic between London and Paris, and perhaps between London and Manchester, Liverpool and Glasgow. But an analysis of this traffic would probably show that the lines are not used, as a rule, by the commercial or manufacturing communities, but by stockbrokers for the purpose of buying and selling stocks. Communication between London and Paris is almost exclusively to this end, and, I believe, the same applies to the use which is made of the new trunk line between London and Glasgow.

The fact is explained by the high rates charged, which stockbrokers can afford to pay and others cannot. Thus the curious circumstance is brought out that the public money voted by Parliament to the Post Office for the development of telephonic communication is being devoted mainly to the benefit of one class, and that a class not generally esteemed the most reputable of the community.

Having briefly summarised the present position of telephones in the United Kingdom, I will ask the members of this Society to accompany me in spirit to Norway and there ascertain what has been done by municipalities with the object of bringing home the telephone to every business man, and of allowing those who desire it the luxury of telephonic communication in their private houses.

It may be remembered that the late Postmaster-General stated in the House of Commons that telephones in this country must always remain a facility to be enjoyed by the rich, and that even if by low rates a very large circle of subscribers could be obtained, the technical and engineering obstacles in the way of connecting them to an effective exchange were insuperable. Of course, no practical telephone man believes that, even in this country; and abroad the statement of Mr. Arnold Morley has created much amusement, for foreigners have in their own cities, and even in their own villages, proofs before their eyes that the statement is inaccurate.

I recently made a minute inspection of the telephone system of Trondhjem, which is the third town of Norway, and possesses about 30,000 inhabitants. The original telephone exchange was commenced in 1882 by a Mr. L. Spörck, who had obtained a concession from the Town Council. Mr. Spörck secured a considerable number of subscribers, which was not surprising, seeing that his charges amounted only to £2 10s. per annum for a place of business, and £1 5s. per annum for a private house, rates which applied to distances not to exceed about an English mile. But the service given was not entirely satisfactory, and in 1889 the Town Council determined to purchase Mr. Spörck's system, and thereafter manage the telephone business itself. Mr. Spörck having been paid the sum of £1,833 for all his rights, the Town Council proceeded to reconstruct his system in the most substantial and modern manner, a proceeding which, no doubt, provided a good telephone exchange, but which burdened the town with nearly £2,000 of superfluous capital at the start, inasmuch as the value of Spörck's material when taken down was so small, that the purchase money paid was not represented by any valuable asset.

The capital expenditure, including the aforesaid purchase money, now stands at £7,979, with which sum 780 exchange and eight private

* Read before the Northern Society of Electrical Engineers, Manchester, November 11th, 1895.

lines have been constructed. The total number of lines being thus 788, it follows that each line has cost the town, on an average, £10 2s. 6d. The population of the town being 30,000, there is one exchange telephone to each 38 inhabitants. In the United Kingdom the proportion is in 636.

The rates fixed by the Town Council were rather higher than those of Mr. Spörck, but are not, nevertheless, such as would be considered at all excessive in this country.

They are as follows:—

	Per annum. £ s. d.
For a telephone exchange line connecting a place of business not exceeding 1½ kilometres (about one mile) from the central station	3 6 7½
For a second business connection for the same person or firm	2 13 3
For a private house, not exceeding 1½ kilometres from the central station	1 13 4

Should lines exceed in length 1½ kilometres, these charges are increased by 5s. 6d. per annum for each 100 metres in excess.

These charges include all payments. The Town Council supplies all the lines and instruments, and maintains them. It is necessary to take particular note of this fact, because in some places in Norway and other countries subscribers buy their own instruments and pay the cost of their lines, circumstances which have sometimes been put forward as applying universally to all cheap Continental rates; but they are the exception, not the rule. At the middle of last October the value of the subscriptions on the books amounted to 38,300 kronor; and the number of exchange telephones being 780, the average revenue per telephone was 49·1 kronor, or £2 14s. 4d. per annum.

The Town Council, Trondhiem, consists of a burgomaster, 12 aldermen, and 36 councillors. The telephone business is managed by a telephone committee composed of two of the aldermen, and one member of the committee being always a practical engineer.

The committeemen retain their position for four years, and are thus able to obtain a thorough grasp of the business. Acting under the committee is a manager and engineer who has qualified in the latter capacity in the Trondhjem Technical School, and acquired considerable telephonic experience in other Norwegian towns.

The capital is provided out of the rates, but interest at the rate of 4½ per cent. per annum is charged against the telephone system, so that the ratepayers not only lose nothing by the concern but even make a good profit.

It should here be mentioned that the tariff given above is subject to alteration by the Town Council, if such a course should appear desirable, so that the income may be adjusted to the expenditure, and any increase of cost in working thrown upon the telephone subscribers, and not upon the ratepayers.

It is, however, satisfactory to note that the tariff has sufficed hitherto, not only to cover the working expenses, to provide interest on the capital, to create a reserve fund of 5 per cent. per annum on the capital expended, to insure all the employees against death, accident and sickness, but to leave a small surplus every year.

One of the many noticeable differences between government, private, and municipal control of telephones is the fact that the German and other Continental governments, like our own Post-Office, render no accounts that outsiders can understand. The figures published do not distinguish between the telegraph and the telephone; details of cost, salaries, &c., are carefully avoided, so that criticism is disarmed for want of material. Quite different is the procedure of the Continental telephone companies, whose accounts are models of precision and present all the necessary facts, together with the results obtained, in a plain and business-like manner. The municipality of Trondhjem imitates this praiseworthy example, and, having nothing to conceal, sees no harm in taking the public entirely into its confidence.

I am, therefore, able to place very exact details of the cost and results of the Trondhjem system before the society.

Every year a budget or estimate of receipts and expenses for the ensuing year is prepared for, and sanctioned by, the Town Council. The following return shows in the first column the budget for 1894, and in the second column the results actually obtained for that year. The third column shows the items on which the budget estimate was exceeded, and the fourth those which failed to come up to the estimated figures.

It will be seen that the estimated receipts were exceeded by 607·26 kronor, whereas the estimated expenses were only increased by 10·15 kronor.

Comparison of the Budget for 1894 with the Results Actually Obtained.

1 krone = 1s. 1½d. 18 kronor = £1.

Receipts.

	Budget estimate.	Actual accounts.	Excess over Budget.	Under Budget.
	Kr.	Kr.	Kr.	Kr.
Subscriptions received	34,307·00	34,320·51	14·51	...
Trunk line fees ...	...	153·65	153·65	...
Sundry receipts ..	593·00	1,032·10	439·10	..
Kronor	34,900·00	35,507·26	607·26	...

Expenditure.

	Kr.	Kr.	Kr.	Kr.
Interest on capital and depreciation ...	12,471·39	11,549·83	921·56	...
Salaries	15,612·00	14,873·01	738·99	...
Law expenses ...	600·00	640·35	...	40·35
Rent	1,000·00	1,000·00	...	...
Cleaning	170·00	170·36	...	0·36
Office requisites and printing	600·00	1,035·50	...	435·50
Material for repairs ...	2,500·00	3,334·73	...	834·73
Bad debts	500·00	475·00	25·00	...
Insurance premiums...	325·00	353·80	...	28·80
Sundry expenses ...	521·61	877·57	...	335·96
Kronor	34,300·00	34,310·15	1,685·55	1,695·70

The next table is the budget estimate, in greater detail for the current year, 1895, with its principal items converted into English money.

Budget for 1895.—Receipts.

First Half-Year—

481 subscriptions at	Kr. 30 (£1 13s. 3d.)	Kr. 14,430·00	
192 „	„ Kr. 15 (£0 16s. 7d.)	„ 2,880·00	
40 „	„ Kr. 24 (£1 6s. 7½d.)	„ 960·00	
			Kr. 18,270·00

Second Half-Year—

491 subscriptions at	Kr. 30 (£1 13s. 3d.)	Kr. 14,730·00	
202 „	„ Kr. 15 (£0 16s. 7d.)	„ 3,030·00	
40 „	„ Kr. 24 (£1 6s. 7½d.)	„ 960·00	
			Kr. 18,720·00
Excess subscriptions for extra distances		(£38 17s. 8d.)	700·00
Trunk lines fees		(£27 15s. 6d.)	500·00
Receipts from four public stations ...		(£3 17s. 8d.)	70·00
Sundry receipts		(£30)	540·00
			Kr. 38800·00
			(£2,155 11 0)

Expenditure.

Interest at 4½ per cent. on Kr. 143,636·33 ...		Kr. 6463·63	(£359)
Depreciation at 5 per cent. on „ ...		7181·82	(£399)
			13645·45

Salaries and Wages—

Manager and engineer (£150 per year) ...	2700·00	
Storekeeper and clerk (£66 13s. 3d. per yr)	1200·00	
Lady superintendent (£3 6s. 8d. per month)	720·00	
Six girl operators at Kr. 600·00 (£2 15s. 5½d. per month)	3600·00	
Seven girl operators at Kr. 480·00 (£2 4s. 5d. per month)	3360·00	
One reserve operator, nine months at Kr. 40 (£2 4s. 5d. per month)	360·00	
One reserve operator, six months at Kr. 40 (£2 4s. 5d. per month)	240·00	
Five linemen at Kr. 780·00 (£43 6s. 8d. per year)	3900·00	
Allowance to foreman (£6 13s. 3d. per year)	120·00	
Messenger (£23 6s. 8d. per year)	420·00	
		16620·00

Sundries—

	£ s. d.	
Reserve operators for emergencies, retaining fees	(33 6 8)	600·00
Light and firing	(55 11 0)	1000·00
Cleaning	(9 8 10)	170·00
Stationery and printing...	(33 6 8)	600·00
Material for repairs	(138 17 8)	2500·00
Bad debts	(16 13 3)	300·00
Insurance premiums	(14 8 10)	260·00
Sundry expenses	(22 8 10)	404·55
		Kr. 36100·00
		(£2,005 11 0)

It will be seen that a profit of Kr. 2,700, or £150, was anticipated in the Budget, but when in Trondhjem last month (October) I was assured that the estimate of receipts, both for local subscriptions and trunk line fees, had been already more than realised.

The estimate provides for an increase of only 45 subscribers for the whole year, whereas in October 84 had already been obtained, and the revenue stood at 38,300 Kroner instead of the estimated 36,990. Instead of new orders ceasing with the growth of the exchange, as it was feared by some that they would, they are coming in faster than ever, and it is in contemplation to instal next year a multiple switchboard of the most modern type for the purpose of providing adequately for future business.

(To be continued.)

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Compiled expressly for this journal by* W. P. Thompson & Co. *Electrical Patent Agents*, 31, *High Holborn, London, W.C., to whom all inquiries should be addressed. Copies of any of the specifications may be obtained of* Messrs. W. P. Thompson & Co., *price, post free*, 8½*d. (in stamps.)*]

NEW PATENTS.—1895.

20,288. "Improvements in electric railways," W. S. Hull. Dated October 28th.

20,296. "Improvements in devices for operating the starting, reversing, and stopping gear of machinery or motors, more particularly applicable to lifts." W. P. Thompson. (J. Dulait, Belgium). Dated October 28th.

20,301. "An improved machine for sweeping and cleaning chimneys, also for pushing and dragging lines or ropes through tubes or pipes for electrical or other purposes." D. Walker. Dated October 28th.

20,306. "Improvements in electric power storage batteries or accumulators." J. Langelaan. Dated October 28th.

20,335. "Improvements in electric arc lamps." P. Collinson. Dated October 29th.

20,392. "Improvements in and relating to arc lamps." M. Wheless. Dated October 29th.

20,431. "Improvements in secondary batteries." J. J. Rooney. Dated October 29th.

20,435. "Improvements in electric brakes." J. Devonshire. Dated October 29th.

20,487. "Improvements in connection with electric indicators for signalling between signal box and station platform." E. W. Cheyney. Dated October 30th.

20,498. "The novel application of electricity for lighting purposes." C. H. Taylor and J. Taylor. Dated October 30th.

20,508. "Improvements in non-synchronous alternate current motors." V. A. Fynn and Easton, Anderson and Goolden, Ltd. Dated October 30th.

20,509. "An improved system and means for electrical distribution by alternating currents." V. A. Fynn and Easton, Anderson and Goolden, Limited. Dated October 30th.

20,510. "Improvements in dynamos and motors." V. A. Fynn and Easton, Anderson and Goolden, Limited. Dated October 30th.

20,529. "Improvements in the construction of electric railways." M. Cattori. Dated October 30th.

20,542. "Improvements in or connected with apparatus for the electrolytic decomposition of brine." G. Bell and G. W. Bell. Dated October 31st.

20,572. "Improvements in and relating to the active material for secondary electric batteries." C. Marschner. Dated October 31st.

20,595. "A device for improving the contact of the wires connecting the several rails of electric tramways." C. D. Hastedt. Dated October 31st.

20,600. "Improvements in electric incandescent glow lamps." R. J. Bott. Dated October 31st.

20,626. "Improvements in electric arc lamps specially applicable for lantern purposes." F. W. Branson. Dated November 1st.

20,636. "Improvements in or relating to telephone instruments." T. F. J. Truss. Dated November 1st.

20,639. "An improved system of wiring buildings and other places for the fitting up of electric light installations." J. Jennings and E. W. L. Harrison. Dated November 1st.

20,681. "Improvements in and relating to the ventilation of transformer boxes, conduits, and the like, used in the distribution of electrical energy." L. Penson. Dated November 1st.

20,696. "Improvements in electric switches." F. H. Nalder and A. Soames. Dated November 1st.

20,719. "An electric maximum current indicator." F. W. E. Jones. Dated November 2nd.

20,728. "Improvements in electric tramcar system." A. C. Brown and G. R. Neilson. Dated November 2nd.

20,734. "Improved bowl for electric and other lamps." A. J. Boult. (J. L. Spink and T. W. Hern, Canada.) Dated November 2nd.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

1895.

3,679. "Improvements in the construction of electric arc lamps." T. S. Foster, 38, Blackett Street, Newcastle-on-Tyne. Dated February 20th. Relates to an improved construction of solenoid for the regulation of the distance between the carbons, formed of a tube which may have a solid wall for continuous current lamps or may be slotted along its entire length where alternating currents are used and is surrounded by a helically coiled wire. At the lower end is a cross piece which carries on each side of said solenoid, a pulley, an insulated binding screw, and an insulated downwardly projecting rod. 1 claim.

12,622. "Improvements in secondary or accumulator cells." A. Muller, 90, Bergstrasse Hagen, Westphalen, Germany. Dated June 29th. The wall of the cell is used as the negative terminal electrode, the positive electrodes being suspended from the walls by glass rods or supported on insulating feet on the bottom of the cell. The positive terminal is insulated from the negative body of the cell where it passes out and the cell is hermetically sealed. 3 claims.

12,953. "Manufacture of chloride of lead." The Chloride Electrical Storage Syndicate, Limited. Clifton Junction, near Manchester, and J. G. A. Rhodia, Clifton Hall, near Manchester, Lancs. Dated July 4th. Claim the herein described manufacture of chloride of lead by subjecting litharge to the action of hydrochloric acid at high temperature and pressure. 1 claim.

12,954. "An improvement in secondary voltaic batteries." The Chloride Electrical Storage Syndicate, Limited, Clifton Junction, near Manchester, and G. A. Grindle, Addiscombe, Prestwich. Dated July 4th. Refers to specification No. 1,229 of 1893, in which is described the arrangement in which each positive plate of a secondary voltaic battery having a number of holes charged with active material, is covered on both sides with acid proof fabrics and is separated from the negative plates on each side of it by distance pieces, which have holes corresponding to those in the plate and have vertical channels for passage of the exciting liquid from hole to hole. According to the present invention the distance piece is a plate made of ebonite or such like material with holes through it corresponding with the holes of the battery plates. It has a marginal rib at each side and between the holes are short longitudinal ribs projecting the same distance from the face of the plate as the marginal rib. When the plate is placed between two battery plates closely pressed against it, the ribs keep the flat surface on one side away from the adjacent battery plate, so that there is a free passage for the exciting liquid between the ribs from hole to hole. 1 claim.

13,205. "Improvements in electrical transmission of energy for telegraphic signalling." M. J. Pupin, 46, West 72nd Street, New York, U.S.A. Dated July 9th. Relates to multiple telegraphic signalling by means of alternating currents of different frequencies sent along the same line. At the receiving end means are described for selecting the currents of the different frequencies and causing them to operate sounders or other receiving instruments. These means broadly consist in making circuits each of which responds or is resonant more to currents of one frequency than of any other frequency. The circuits are attuned to the proper frequency by varying the impedance capacity and self-induction of the same. 3 claims.

13,635. "Improvements in electric gas lighters." H. G. Grier and A. G. Grier, of 735, N. 43rd Street, Philadelphia, and A. S. Hottle, of 4,606, Wayne Street, Germantown, Pa., U.S.A. Dated July 16th. Comprises the combination in an electric gas lighter, of the shade holder carrying a crown, the outer portion of the crown being insulated from the inner portion and forming one terminal of the lighter, a magnet carried by the shade holder, an armature and a movable terminal connected to the armature and adapted to come into contact with the portion of the crown forming the other terminal. 6 claims.

13,978. "Improvements in the method of and means for stopping electrically propelled cars." A. K. Bonta, 200, Eleventh Street, Hoboken, N.J., U.S.A. Dated July 23rd. Relates to a method of stopping electrically propelled cars by utilising the momentum of the car, the motors being disconnected from the main leads. For this purpose a switch is arranged to reverse the connections of the armature to the field of each motor, and as the car continues to run the armature generates the current which passes round the field in the same direction as the ordinary line current does at the same time the attraction between the fields and armatures tends to stop the motors and thus utilises a momentum of the car. 5 claims.

14,023. "Improvements in writing telegraphs." P. A. Newton, 6, Bream's Buildings, Chancery Lane, London. (Thos. Ewing, junior, 132, Locust Hill Avenue, Yonkers, U.S.A.) Dated July 23rd. Describes a two-wire writing telegraph or telautograph system, in which the fundamental telautographic operations of moving the pen and controlling its direction of movement in horizontal planes, of lifting and lowering the pen, and of shifting the paper, at the receiver, are effected by actual currents transmitted over the lines, by the operation of the transmitter, and not by a mere cessation of transmission of currents, also in a system of switches and electrical connections whereby it is possible, when operating over two lines, to transmit to these lines different sets of currents to effect these fundamental telautographic operations at the receiver, which different sets of currents shall include currents of both polarities, also a transmitter so organised that the movements of the transmitter-pen will cause such currents to be sent to line; and of a receiver so organised that under the influence of such currents the receiver-pen will follow the movements of the transmitter-pen, both as to extent and direction of motion. Twelve claims.

14,481. "An improvement in imitation candles for electric lights." T. G. Poole, 11, Queen Victoria Street, London, and W. Lowry, 48, Margaret Street, London. Dated July 30th. Relates to means for fitting on a suitable stem carrying an electrical glow lamp, the porcelain or enamel cylinder which imitates a candle. The stem is provided as usual with a plug of caoutchouc or other elastic material to be inserted in the socket of a candlestick, and the socket to receive the glow lamp. On the stem is placed a star-shaped washer of caoutchouc, or several of these, over which is drawn the porcelain or enamel tube. Notwithstanding variations in the diameter of the tubes, the washers serve to hold it in position, properly centreing the stem, as the elastic rays of the washers admit of considerable flexure and compression. 1 claim.